TASC

THE ANALYTIC SCIENCES CORPORATION

AD-A240 483

A-332

TIME DISTRIBUTION OF BELOW-THE-LINE COSTS FOR GPALS ELEMENTS

15 July 1991

Prepared for:

Deputy For Program Operations
Cost Estimating and Analysis Directorate
THE STRATEGIC DEFENSE INITIATIVE ORGANIZATION
The Pentagon
Washington, D.C. 20301-7100

under:

Contract Number SDIO84-88-C-0018
Task Order 42

A-1

Prepared by:

Robert J. Winklareth

91-10749

TASC
1101 Wilson Boulevard
Suite 1500
Arlington, Virginia 22209

TASC
THE SPARTA ARI SRC DBA
THE INTEGRATED SETA TEAM COMMITTED TO SDIO

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (Continued)

1. INTRODUCTION

1.1 PURPOSE

This report documents the results of a study to determine the means for improving the accuracy and credibility of below-the-line (program level) cost estimates for elements of the Global Protection Against Limited Strikes (GPALS) System and for distributing total program costs for each below-the-line cost element on an annual basis throughout each acquisition phase.

1.2 SCOPE

This report applies to costs associated with the development and production of defense systems. It pertains primarily to contractor below-the-line costs, including the cost of contractor support for government activities, but not contractor general and administrative costs, fees, or the cost of money. The report does not cover the costs incurred by government activities involved in defense system acquisition, such as the cost of government program offices, training, test and evaluation, transportation, launch support, and scientific, engineering, and technical assistance (SETA) contractors providing direct support to government activities.

This report addresses the engineering and manufacturing development (EMD) phase [formerly called full-scale development (FSD) phase] and the production phase of defense system acquisition programs. It does not address the demonstration/validation (Dem/Val) phase or the operation and support phase of defense systems since the available data only covered the EMD and production phases.

1.3 DEFINITIONS

Above-the-line (A-T-L) costs are defined as the basic engineering and manufacturing costs associated with the design, development, and production of a defense system. For development programs, A-T-L costs cover:

- Design activities

- Development engineering
- Producibility engineering and planning (PEP)
- Manufacturing methods and technology
- Development tooling
- Prototype manufacturing
- System integration and assembly.

For production programs, A–T–L costs cover:

- Nonrecurring investment such as initial production facilities (IPF), production base support (PBS), and depot maintenance plant equipment (DMPE)
- Manufacturing and assembly
- Sustaining tooling
- Recurring engineering
- Quality control
- Engineering changes (configuration management).

Below-the-line (B–T–L) costs are defined as the supplemental program level costs associated with support for the development, production, and initial deployment of a weapon system. B–T–L costs cover:

- System/program management, including system engineering, specialty engineering (reliability, maintainability, safety, human factors, logistics, etc.), and project management
- System test and evaluation
- Data, including engineering data, management data, logistic support data, provisioning data, and technical publications
- Training services, equipment, and facilities
- Peculiar support equipment
- Facilities and operational/site activation
- Initial spares.

1.4 OBJECTIVES

The specific objectives of this study were to:

- Determine whether any actual relationships exist between B–T–L and A–T–L cost elements on a time–phased basis, and if so, develop specific factors for such cost estimating relationships.
- Determine whether any actual trends exist with B–T–L cost elements on a time–phased basis, and if so, develop specific factors for allocating total program costs on a year–by–year basis throughout each acquisition phase.

1.5 BACKGROUND

Existing cost estimating relationships (CERs) for each B–T–L cost element are based on a single percentage of total A–T–L costs or a combination of different percentages of various A–T–L cost elements for the total development or production phase of a defense system program. For example, the cost of Data for certain GPALS elements is equal to 0.314 times the total cost of Development Engineering, Prototype Manufacturing, and System Test and Evaluation in the EMD phase.

One way of breaking down B–T–L costs on a time–phased basis is to apply a factor based upon past experience to determine the percent of the total program cost that is expected to be incurred at 50 percent completion of that phase. Such factors were developed by Tecolote Research, Inc. in the form of "Beta Curves" for Air Force electronic systems managed by the Electronic Systems Division (ESD) of the Air Force Systems Command (AFSC). While useful for budgeting for each half of the phase, this method does not permit budgeting on a year–by–year basis throughout the phase.

In December 1990, this study was initiated to investigate cost estimating relationships and trends in B–T–L cost elements on an annual basis. The study is based primarily on historical contractor cost performance data for selected high–technology, state–of–the–art defense system acquisition programs. The results were checked for consistency against related government program cost data and known activities in the defense system acquisition process. The results to date are interim and subject to further refinement as additional data are obtained and analyzed.

1.6 PARTICIPANTS AND CONTRIBUTORS

The following TASC personnel participated in the study of B–T–L costs in the areas indicated:

- David Gallina (data collection)

- David Olsen (project guidance)
- Jim Sunderlin (data analysis)
- Bob Winklareth (methodology)
- Larry Wolfarth (analytic techniques)

The following activities contributed to this study, primarily in providing the necessary data for the analysis conducted:

- Air Force Systems Command (AFSC)
  - Aeronautical Systems Division (ASD)
  - Electronic Systems Division (ESD), especially Ms. Ellen Coakley.
- Navy
  - NAVAIR
  - NAVSEA
- Army
  - Strategic Defense Command (SDC)
- Contractors
  - Applied Research, Inc.
  - Tecolote Research, Inc., especially Mr. Tom Kielpinski

1.7 ACRONYMS AND ABBREVIATIONS

Acronyms and abbreviations used in this report are listed in Appendix A.

1.8 REFERENCES

Department of Defense (DoD) and Military Service directives, regulations, and instructions applicable to this report are listed in Appendix B.

2. METHODOLOGY

This section addresses the methodology used to accomplish the objectives of this study.

2.1 ACQUISITION ACTIVITIES

The first step in the analysis process was to review the major activities performed in the acquisition cycle. The acquisition of all major defense systems generally follows the same pattern and involves the same basic requirements for products and services throughout the acquisition cycle. This standardization is due primarily to policies and procedures established at the DoD level and supplementary guidance provided by each of the Military Services to their program offices. An analysis of the major activities performed in each phase of the acquisition cycle provided an indication of the level of effort that has to be funded on a year-by-year basis during that period.

2.2 PROGRAM FUNDING PROFILES

Funding profiles for a number of defense programs reported in DoD Selected Acquisition Reports (SARs) were reviewed to determine annual trends in research, development, test, and evaluation (RDT&E) costs and production costs for major defense systems. This data served as the baseline for comparing annual fluctuations in A–T–L and B–T–L costs. Funding profiles for a number of current and past defense system development and production programs are presented in Appendix D.

2.3 CONTRACTOR COST DATA

Historical contractor data on annual costs for various cost elements in current and past development and production programs were obtained from several sources, including:

- Contractor Cost Performance Reports (CPRs), Cost Data Summary Reports (CDSRs), and similar reports
- Government data bases that include historical contractor cost data, such as the Automated Cost Estimating — Integrated Tools (ACE–IT) data base

of the Electronics Systems Division (ESD), Air Force Systems Command (AFSC)

- Government reports, such as Cost Factors for Aircraft and Missiles, May 1987, issued by Aeronautical Systems Division (ASD), AFSC.
- Other sources of information on individual systems as available.

Historical contract data from different sources varied considerably in format. These variations were often due to different work breakdown structures (WBSs) prescribed by the Military Services (see paragraph 3.6 and Appendix C). There were even variations in CPR format for different programs within the same Service. To aid in the collation of contract cost data from different sources, standard WBSs were developed for the development phase and production phase, as shown in Tables 2.3-1 and 2.3-2, respectively.

Table 2.3-1 Standard WBS for Development Program Cost Elements

1.	Total Program Development Costs
1.1	Total Government Costs
1.1.1	System/Program Management
1.1.1.1	Program Office
1.1.1.2	Other Government Activities
1.1.1.3	SETA Contractor Support
1.1.1.4	Other Program Management Costs
1.1.2	System Test and Evaluation
1.1.2.1	Development Test
1.1.2.2	Operational Test
1.1.2.3	Range Support
1.1.2.4	Target Support
1.1.2.5	Launch Support
1.1.2.6	Other Test and Evaluation
1.1.3	Training
1.1.4	Other System Development Costs
1.1.5	Launch Costs
1.1.6	Other Program-related Government Costs
1.2	Total Contractor Costs
1.2.1	Total A-T-L Costs
1.2.1.1	System Development
1.2.1.1.1	Integration and Assembly
1.2.1.1.2	Hardware Development
1.2.1.1.3	Software Development

Table 2.3-1 Standard WBS for Development Program Cost Elements (Continued)

1.2.1.2	Development Engineering
1.2.1.2.1	Engineering Activities
1.2.1.2.2	Producibility and Manufacturing Methods
1.2.1.2.2.1	Producibility Engineering and Planning (PEP)
1.2.1.2.2.2	Manufacturing Methods and Technology (MMT)
1.2.1.2.3	Tooling
1.2.1.2.4	Prototype Manufacturing
1.2.1.2.4.1	Integration and Assembly
1.2.1.2.4.2	Component Fabrication
1.2.1.3	Other A-T-L Costs
1.2.2	Total B-T-L Costs
1.2.2.1	System/Program Management
1.2.2.1.1	Project Management
1.2.2.1.2	System Engineering
1.2.2.1.3	Integrated Logistics Support
1.2.2.1.4	Other System/Program Management Costs
1.2.2.2	System Test and Evaluation
1.2.2.2.1	Contractor Testing
1.2.2.2.2	Contractor Support of Government Testing
1.2.2.3	Data
1.2.2.3.1	Engineering Data
1.2.2.3.2	Logistics Data
1.2.2.3.3	Technical Publications
1.2.2.3.4	Management Data
1.2.2.3.5	Other Data
1.2.2.4	Training
1.2.2.4.1	Training Services
1.2.2.4.2	Training Equipment
1.2.2.4.3	Training Facilities
1.2.2.5	Development Facilities
1.2.2.6	Support Equipment
1.2.2.7	Other B-T-L Costs

Table 2.3-2 Standard WBS for Production Program Cost Elements

1.	Total Program Production Costs
1.1	Total Government Costs
1.1.1	System/Program Management
1.1.1.1	Program Office
1.1.1.2	Other Government Activities
1.1.1.3	SETA Contractor Support
1.1.1.4	Other Program Management Costs
1.1.2	System Test and Evaluation
1.1.2.1	Government Test
1.1.2.2	Range Support
1.1.2.3	Target Support
1.1.2.4	Launch Support
1.1.2.5	Other Test and Evaluation
1.1.3	Training
1.1.4	Operational/Site Activation
1.1.5	Transportation
1.1.6	Other System Production Costs
1.1.7	Launch Costs
1.1.8	Other Program-related Government Costs
1.2	Total Contractor Costs
1.2.1	Total A-T-L Costs
1.2.1.1	System Production
1.2.1.1.1	Integration and Assembly
1.2.1.1.2	Component Production
1.2.1.2	Investment and Production
1.2.1.2.1	Nonrecurring Investment
1.2.1.2.1.1	Initial Production Facilities (IPF)
1.2.1.2.1.2	Production Base Support (PBS)
1.2.1.2.1.3	Depot Maintenance Plant Equipment (DMPE)
1.2.1.2.1.4	Other Nonrecurring Investment
1.2.1.2.2	Recurring Production
1.2.1.2.2.1	Manufacturing
1.2.1.2.2.2	Recurring Engineering
1.2.1.2.2.3	Sustaining Tooling
1.2.1.2.2.4	Quality Control

Table 2.3-2 Standard WBS for Production Program Cost Elements (Continued)

1.2.1.2.2.5	Other Recurring Production
1.2.1.2.3	Engineering Changes
1.2.1.3	Other A-T-L Costs
1.2.2	Total B-T-L Costs
1.2.2.1	System/Program Management
1.2.2.1.1	Project Management
1.2.2.1.2	System Engineering
1.2.2.1.3	Integrated Logistics Support
1.2.2.1.4	Other System/Program Management Costs
1.2.2.2	System Test and Evaluation
1.2.2.2.1	Contractor Testing
1.2.2.2.2	Contractor Support of Government Testing
1.2.2.3	Data
1.2.2.3.1	Engineering Data
1.2.2.3.2	Logistics Data
1.2.2.3.3	Technical Publications
1.2.2.3.4	Management Data
1.2.2.3.5	Other Data
1.2.2.4	Training
1.2.2.4.1	Training Services
1.2.2.4.2	Training Equipment
1.2.2.4.3	Training Facilities
1.2.2.5	Operational/Site Activation
1.2.2.6	Initial Spares
1.2.2.7	Support Equipment
1.2.2.8	Other B-T-L Costs

The standard formats developed included government costs and total program costs as well as contractor costs so that complete program cost data for each defense system could eventually be incorporated into the data base. By having complete program costs, it is then possible to compare relationships between government costs, contractor A–T–L costs, contractor B–T–L costs, and total program costs and to ensure consistency between data derived from difference sources on the same program.

Since the available data were primarily in "then-year" dollars, the cost values were all converted to constant FY91 dollars. While this did not affect the ratios between different cost elements for the same system in the same year, it did affect the comparison of actual dollar values for various programs that started in different calendar or fiscal years. Normalizing the cost data

also enabled calculations to be made without fear of distorting the results by ignoring the impact of inflation through the use of "then-year" dollars.

2.4 COLLATION OF DATA

Historical contractor cost data for each system, broken down by cost element, were collated by phase year, beginning with the first year of each program phase, to permit comparison of data for different systems in the same time frame. The start of each phase for a program was determined from the Selected Acquisition Report (SAR) for that program, Jane's publications on defense systems, Service reports, and other credible sources. The data were also collated by cost element to allow for a direct comparison of time-phased trends in each cost element among various programs.

It was essential that complete data for each year of the development or production phase of the system be obtained for comparing the time-phased trends of the various cost elements. Isolated data points cannot be averaged since the magnitude of those data points could distort the statistics for each cost element unless part of a complete data set for that phase. A cursory comparison of the average of isolated data points to the average of data points in complete sets of data showed little correlation and therefore tended to support our conclusion.

In view of the limited data available, several techniques were used to enhance the database. Where a single value was missing in a data set for a cost element over the total phase for that program, the value for the missing year was estimated where that value was consistent with the other data points; i.e., followed a definite trend line. Deltas between two consecutive data points in an incomplete set of data for a phase were compared against the equivalent deltas for complete sets of data, however, this comparison showed little correlation and therefore could not be used to build up the useful database.

Another refinement made to the database involved the adjustment of the phase year of certain programs to achieve more realistic results. The average length of the first year of the programs reviewed was five to six months. In a few cases, the first year included only one or two months of data, making the cost figures for that first year unusually low. Where this condition resulted in an undue influence on the data calculations, the beginning of the program phase was adjusted to incorporate six months of data in the first year with the succeeding twelve month periods representing each year thereafter.

The next step was to segregate the data sets for each program and cost element by phase length to facilitate further the comparison of data in the same time frame. Even though the data was previously collated by phase year, this only aligned the starting point of each program, but not necessarily the rest of the program. Comparing data for the same phase year of programs with different lengths would produce inaccurate results. For example, the fourth phase year would correspond to the middle of an eight-year program when costs could be relatively high due to peak activities in that time frame and to the end of a four-year program when costs may be relatively low as the program winds down. Averaging those costs would completely distort the true trend lines for the cost elements involved.

2.5 COST ELEMENT RATIOS

Since the primary objective of the study was to determine whether any actual relationships exist between B-T-L and A-T-L cost elements on a time-phased basis, calculations were initially made of the ratios between B-T-L cost elements and total A-T-L costs. In the absence of adequate data on specific A-T-L cost elements, only the total A-T-L costs, sometimes referred to as prime mission equipment (PME) costs, could be used for comparison against each B-T-L cost element. This was unfortunate since many existing CERs are based on one or more specific A-T-L cost elements rather than total A-T-L costs.

Calculations were then made of the means, medians, midranges, and biweights of the ratios between B-T-L cost elements and total A-T-L costs in each phase year. The spread of data points was determined by calculating the standard deviation for each data set. These results were analyzed to determine whether any time-phased trends existed with those cost elements in relation to total A-T-L costs.

In addition to data spread calculations, point diagrams were prepared to graphically show the distribution of data points for each B-T-L cost element versus total A-T-L costs. Box diagrams were also prepared to depict the spread and range of that data. Where significant variations in time-phased trends were noted, the basic data were again reviewed for values that deviated greatly from the norm (outliers). Outliers that clearly did not represent the typical trend reflected by the other data points were conscientiously eliminated. A linear regression was then performed to determine whether any relationship existed between B-T-L cost elements and total A-T-L costs.

The ratios between B–T–L cost elements and total A–T–L costs were found to be inconsistent on a time–phased basis and therefore no positive trends could be established. Also, the individual data points were too widespread to establish any clear CERs for B–T–L cost elements in each year of the development or production phase. Existing CERs for B–T–L cost elements based on total program costs for each phase appear to be more valid than individual CERs for each year since they are not affected by annual fluctuations of both A–T–L and B–T–L costs which are often divergent and therefore difficult to predict.

2.6 COST ELEMENT TRENDS

2.6.1 General

When the analysis of ratios between B–T–L cost elements and total A–T–L costs indicated the lack of any consistent relationship on a time–phased basis, the study focussed on an analysis of each individual B–T–L cost element for possible time–phased trends. After the data sets for each B–T–L cost element were segregated by phase length, the means of the costs for that element were calculated for each year in that phase. These means were then analyzed and plotted to determine whether any consistent time–phased trends existed with those B–T–L cost elements.

Table 2.6–1 shows the approximate distribution of B–T–L costs by cost element for development programs and for production programs. Since System/Program Management constitutes the highest percent of B–T–L costs, that element was used to illustrate the methodology used for determining the annual spread of total B–T–L costs based on existing CERs.

Each cost element was then analyzed separately for development programs and production programs of the same phase length. Means of the cost values for different defense systems on which complete data for that phase were available were calculated. Similar systems were grouped for comparison purposes, however, the means for all systems with the same phase length were used in the final analysis.

Table 2.6–1 Distribution of B–T–L Costs

Cost Element	Percent of Total	
	Development Programs	Production Programs
System/Program Management	50	40
System Test and Evaluation	30	10
Data	5	10
Training	5	10
Facilities	(1)	(2)
Operational/Site Activation	(2)	(1)
Support Equipment	10	10
Initial Spares	(2)	20

(1) Variable (mostly zero)

(2) Not applicable to that phase

2.6.2 Development Programs

Tables 2.6–2, 2.6–3 and 2.6–4 show the means of System/Program Management costs for systems with development phase lengths of six years, five years, and four years, respectively. Since CPR data showing a breakdown of contractor costs is proprietary, the actual names of the systems are not shown nor are any actual cost data on those systems. Data points are shown by X's and costs have been converted to percents of the total cost for each element in the development phase.

Table 2.6–2 System/Program Management Costs for Six-Year Development Programs

System	Percent of Total Cost by Phase Year						
	1	2	3	4	5	6	Total
Electronic Systems:							
A	X	X	X	X	X	X	
B	X	X	X	X	X	X	
C	X	X	X	X	X	X	
D	X	X	X	X	X	X	
E	X	X	X	X	X	X	
Mean	4	21	28	21	20	5	100
Missile Systems							
F	3	27	35	22	12	1	100
Other Systems (No Data Available)	--	--	--	--	--	--	--
Mean of All Systems	4	22	29	21	19	4	100

Table 2.6–3 System/Program Management Costs for Five-Year Development Programs

System	Percent of Total Cost by Phase Year					
	1	2	3	4	5	Total
Electronic Systems:						
G	X	X	X	X	X	
H	X	X	X	X	X	
I	X	X	X	X	X	
J	X	X	X	X	X	
K	X	X	X	X	X	
L	X	X	X	X	X	
Mean	5	30	36	23	5	100
Other Systems (No Data Available)	--	--	--	--	--	--

Table 2.6–4 System/Program Management Costs for Four-Year Development Programs

System	Percent of Total Cost by Phase Year				
	1	2	3	4	Total
Electronic Systems:					
M	X	X	X	X	
N	X	X	X	X	
O	X	X	X	X	
P	X	X	X	X	
Q	X	X	X	X	
R	X	X	X	X	
S	X	X	X	X	
Mean	12	46	35	7	100
Other Systems (No Data Available)	--	--	--	--	--

The different data sets for System/Program Management in six-year, five-year, and four-year programs were plotted on the same chart for comparison purposes as shown in Figure 2.6-1. To better judge any similarity in the curves for different program lengths, the data points were again plotted together using different horizontal scales but with the same beginning and end points, as shown in Figure 2.6–2. Since the magnitude of each data set was different, the curves were then normalized by adjusting the maximum value of each set to 100 percent, as shown in Figure 2.6–3.

In the case of System/Program Management costs, the adjusted curves for each program length showed a remarkably close relationship to one another. While a comparison of any two systems might show a considerable variation, the mean curve for each population (group of systems with the same phase length) generally coincided with the mean curves of the other two populations. This supported the belief that B–T–L costs were governed by a standard set of time–phased activities that was independent of program length. Similar results were obtained for

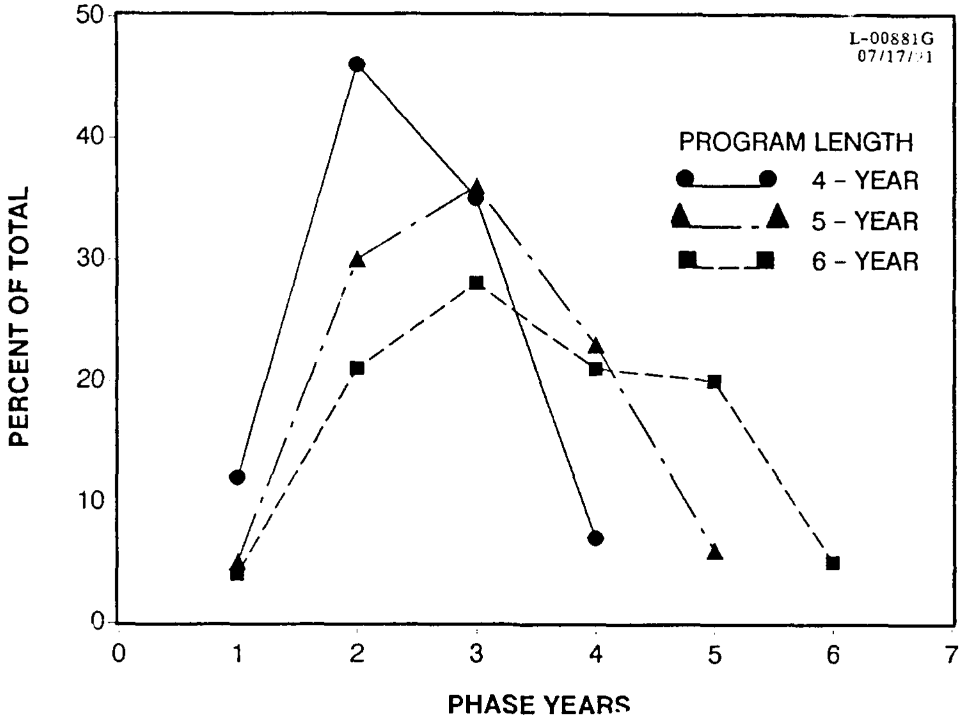

Figure 2.6-1 System/Program Management Costs on Same Scale

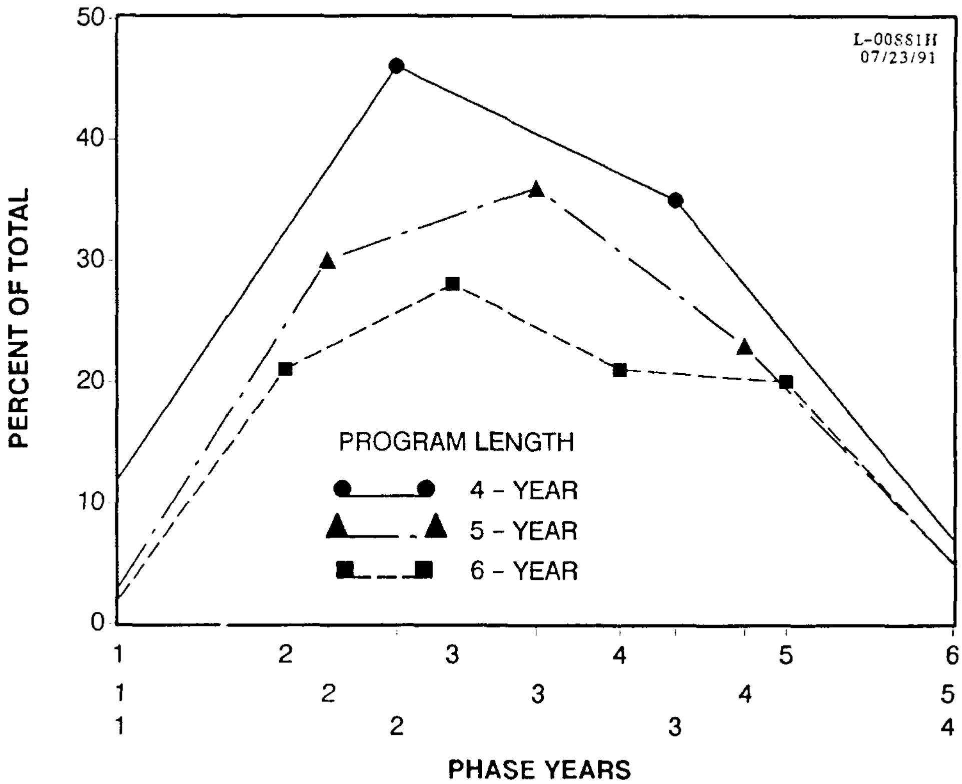

Figure 2.6-2 System/Program Management Costs on Different Scales

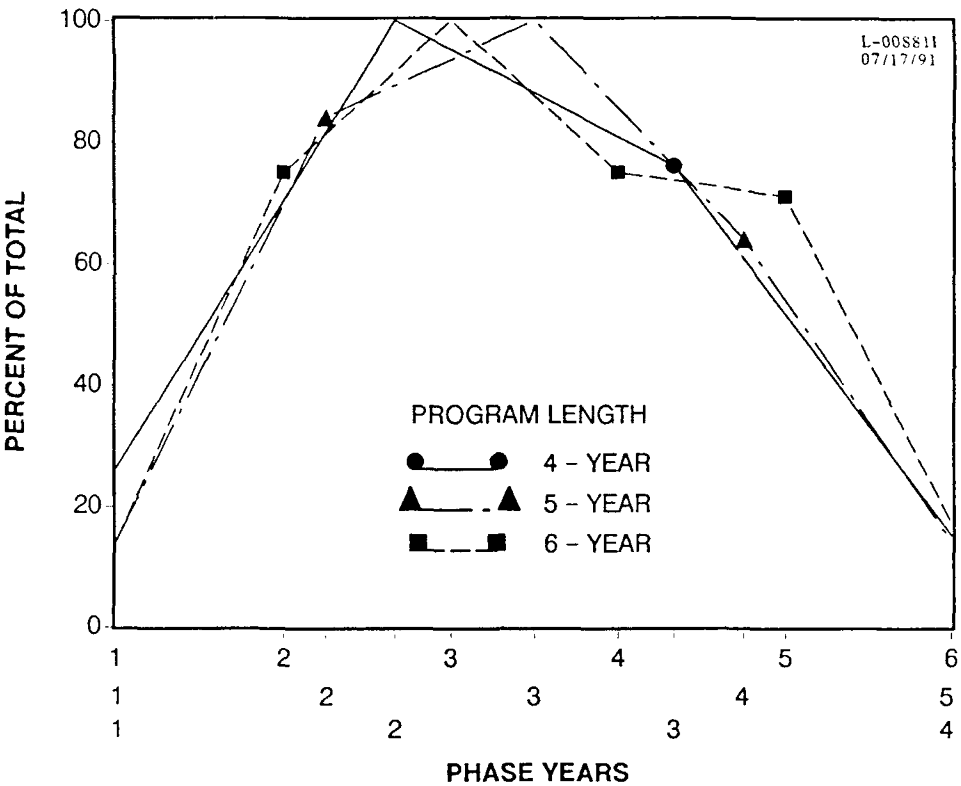

Figure 2.6–3 Normalized System/Program Management Costs

other B–T–L cost elements, but not to the same degree of consistency as with System/Program Management. This was due to a greater degree of cost variation among the other elements.

The actual value of each point on the three curves were determined by interpolation, and averages were then calculated to arrive at a mean curve representing all systems regardless of program length. The resultant curve is graphically depicted for System/Program Management in Figure 2.6–4 which also shows the normalized data points for the six-year, five-year, and four-year program lengths.

Once the mean curve was established, the values for the individual data points were recomputed in terms of percents of total program costs for each B–T–L cost element which constituted the factors for spreading the total program cost for each element by year in each phase. Table 2.6–5 shows the mean value of each data point and the resultant percents of total program costs for System/Program Management.

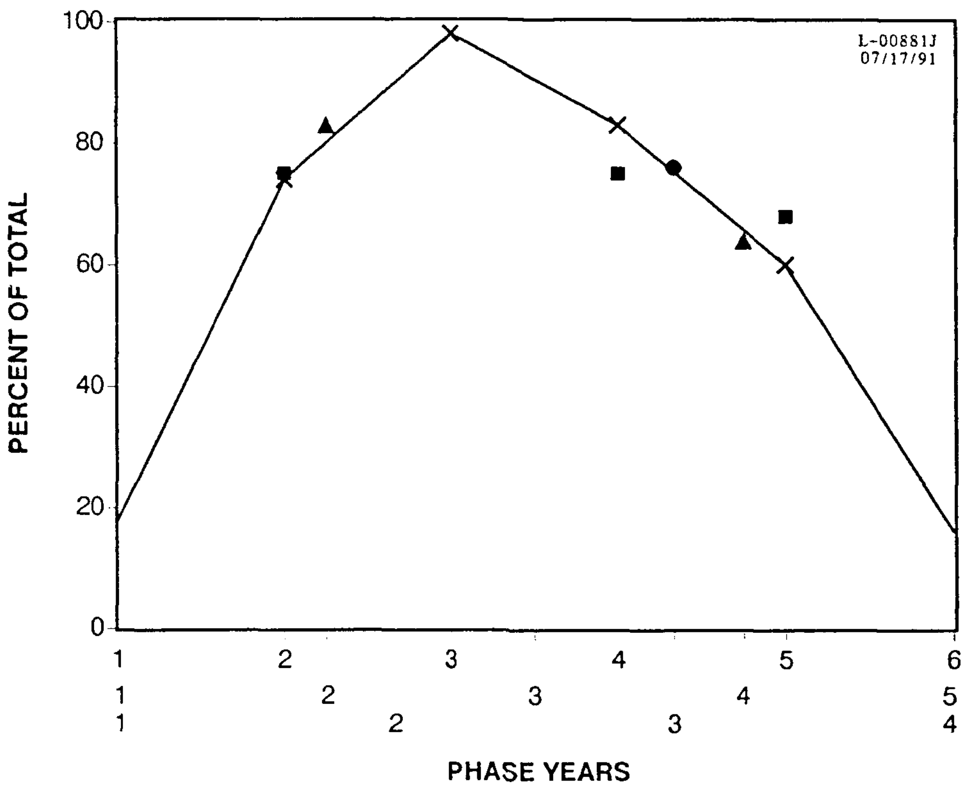

Figure 2.6–4 Mean Curve of System/Program Management Costs

Table 2.6–5 Conversion of Mean Value to Percent of Total System/Program Management Costs of Development Programs

Systems/Data	Phase Year 1	2	3	4	5	6	Total
Four-Year Systems							
Mean Value	17	92	78	17			
Percent of Total Program	9	45	38	9			100
Five-Year Systems							
Mean Value	17	80	91	69	17		
Percent of Total Program	6	29	33	25	6		100
Six-Year Systems							
Mean Value	17	75	100	82	64	17	
Percent of Total Program	5	21	28	23	18	5	100

A comparison of the average annual program costs for System/Program Management determined from the combined data versus the original data for the different phase lengths is shown in Table 2.6–6. Whereas the original data was based on a very limited number of systems (six or seven), the combined data reflects the mean of 19 systems. In view of the very close

relationship between the original curves, the percent variation is not great, however, the results clearly indicate that B–T–L costs are not equal in each year of the program phase and therefore should not be straight lined across the program.

Table 2.6–6 Comparison of Original versus Combined Data for System/Program Management Costs of Development Programs

Systems/Data	Distribution of Costs by Phase Year						
	1	2	3	4	5	6	Total
Four-Year Systems							
Original Data (n=7)	12	46	35	7			100
Combined Data (n=19)	9	45	38	9			100
Five-Year Systems							
Original Data (n=6)	5	30	36	23	5		100
Combined Data (n=19)	6	29	33	25	6		100
Six-Year Systems							
Original Data (n=6)	4	22	29	21	19	4	100
Combined Data (n=19)	5	21	28	23	18	5	100

In another comparison, the annual means of 19 systems on which complete data was available were matched against partial data from a totally different system. While only the last two years of that five–year development program were available, the cost values were highly accurate and therefore excellent for comparison purposes. The results as shown in Table 2.6–7 also suggest that the trends developed from this methodology are valid for a wide range of high–technology, state–of–the–art defense systems.

An analysis of Table 2.6–7 shows that the comparative figures for System/Program Management are virtually identical. In the case of System Test and Evaluation both sets of figures show a significant peak in the fourth year. For Data, the means for the 19 systems show a wider spread than for System X, which peaks in the fourth year. Both sets of figures show a major peak for Training in the fourth year although the means for the 19 systems show some Training in other years while System X incurred almost all of its Training cost in that one year. No data were shown for Facilities or Support Equipment for System X indicating zero values for those cost elements.

Table 2.6–7 Comparison of B–T–L Costs for Five-Year Development Programs

Cost Element	System	Percent of Program Cost by Phase Year				
		1	2	3	4	5
Sys/Prog. Mgmt.	Mean (n=19)	6	29	33	25	6
	System X	(1)	(1)	(1)	25	5
Sys. Test & Eval.	Mean (n=19)	1	10	24	36	29
	System X	(1)	(1)	(1)	41	19
Data	Mean (n=19)	5	26	34	27	8
	System X	(1)	(1)	(1)	45	12
Training	Mean (n=19)	1	5	25	40	29
	System X	0	0	0	95	5
Facilities	Mean (n=19)	2	27	37	27	8
	System X	(2)	(2)	(2)	(2)	(2)
Support Eqmt.	Mean (n=19)	2	28	40	23	8
	System X	(2)	(2)	(2)	(2)	(2)

(1) Data not available

(2) Cost element not included

2.6.3 Production Programs

A somewhat different approach was used for production programs as was used for development programs. System/Program Management was again the cost element chosen to illustrate the methodology since it was the highest cost element for production programs also. Tables 2.6–8, 2.6–9, and 2.6–10 show System/Program Management costs for six-year and longer, four-year, and three year production programs, respectively. Many production programs exceed six years, but that period of time is sufficient to describe the methodology used.

Production programs have different characteristics than development programs. System/Program Management and Initial Spares tend to be relatively level throughout the production phase, but other B–T–L cost elements tend to have the highest costs in the first two years of the phase before leveling off and finally declining at the end of that phase. Production programs of longer length tend to be open-ended after the first three years, i.e., continue until the end of the production phase when costs drop significantly in the final year of that phase. It is therefore not possible to overlay production data sets for different phase lengths to arrive at a mean curve as was done for development programs.

Table 2.6-8 System/Program Management Costs for Six-Year and Longer Production Programs

System	Percent of Six-Year Cost by Phase Year						
	1	2	3	4	5	6	Total
Missile Systems:							
A	X	X	X	X	X	X	
B	X	X	X	X	X	X	
C	X	X	X	X	X	X	
D	X	X	X	X	X	X	
E	X	X	X	X	X	X	
Mean	20	19	15	17	16	13	100
Electronic Systems							
F	7	31	21	14	13	14	100
Other Systems (No Data Available)	--	--	--	--	--	--	--
Mean of All Systems	18	21	16	17	16	13	100

Table 2.6-9 System/Program Management Costs for Four-Year Production Programs

System	Percent of Total Cost by Phase Year				
	1	2	3	4	Total
Electronic Systems:					
G	X	X	X	X	
H	X	X	X	X	
Mean	18	40	31	11	100
Avionics Systems					
I	23	60	16	1	100
Other Systems (No Data Available)	--	--	--	--	--
Mean of All Systems	20	46	26	8	100

Table 2.6-10 System/Program Management Costs for Three-Year Production Programs

System	Percent of Total Cost by Phase Year			
	1	2	3	Total
Electronic Systems:				
J	X	X	X	
K	X	X	X	
Mean	38	44	19	100
Avionics Systems				
L	48	47	6	100
Other Systems (No Data Available)	--	--	--	--
Mean of All Systems	41	45	14	100

In the case of production programs, greater reliance had to be placed on the data set for each phase length which included only three systems each for three and four-year programs and six systems for six-year programs. These data sets were compared against one another and with segments of incomplete data for other systems to establish the time-phased trends and magnitudes for each B-T-L cost element. A comparison with known activities in the production phase was also made to ensure consistency with the data available. Since no data was available on systems with a specific production phase length of five years, the results for five-year programs were determined by interpolation of the results for four-year and six-year programs.

3. ISSUES

Several issues arose during the conduct of this study as described below. These issues are identified to assist in the interpretation of the results of the study.

3.1 LIMITED DATA

Most studies of this nature are handicapped by the lack of sufficient data to achieve optimal results, and this study is no exception. Complete data were obtained primarily on Air Force electronic systems in the development phase and a few other systems in either the development or production phase. Partial data was available on several more systems, including missile systems of the various Military Services, but such data could be used only for rough comparison against complete data sets.

3.2 CONSTANT COSTS

Certain B–T–L cost elements are relatively constant from year to year despite significant changes in total development or production costs. For example, System/Program Management tends to be more stable based upon consistent manning levels for that activity, especially in the production phase. The costs of management and coordination functions performed by a fixed staff are not as greatly affected by wide fluctuations in engineering effort or production levels as are other cost elements. This lack of consistency made it impossible to establish any meaningful CERs between those cost elements and total A–T–L costs.

3.3 TIME DEPENDENCY

Some B–T–L cost elements are dependent on the timeframe in the acquisition cycle when the specific products and services covered by those cost elements are required. For example, the costs associated with System Test and Evaluation, Data, and Training tend to be higher early in the production phase when those items are required to support the deployment of the system. Once the system has been initially deployed, these costs tend to drop even though production

levels remain high for a number of years. This divergency in costs also precluded the establishment of any credible CERs between those cost elements and total A–T–L costs.

3.4 TECHNICAL DIFFERENCES

While reviewing historical data on major weapon systems that have a technical relationship to GPALS elements; i.e., missile, satellite, and electronic systems, it was noted that significant variations in cost data exist even between similar systems. These variations could be due to differences in level of development effort depending upon whether the program is a completely new development or a product improvement of an existing system. To a lesser degree, variations in cost could also be due to technical differences, such as different guidance subsystems, that have a bearing on the cost of those systems.

3.5 UNIQUE REQUIREMENTS

Certain B–T–L cost elements are dependent upon specific requirements of the government that may vary greatly between programs or may be applicable only to selected programs. These cost elements include Facilities in development programs and Operational/Site Activation in production programs. Support equipment requirements may also vary depending upon the degree that common (standard) support equipment may be adequate to meet those requirements and therefore avoid the need for peculiar (development) support equipment. These unique requirements must be specified by the government and since they normally have no direct relationship to A–T–L or other B–T–L costs, their costs must be estimated based on the specific circumstances involved.

3.6 WORK BREAKDOWN STRUCTURE INCONSISTENCIES

There are significant inconsistencies among the WBSs used by the Military Services for cost accounting purposes, as shown in Appendix C. The Air Force and the Navy use WBSs based on those established in MIL–STD–881A which break down A–T–L cost elements into major end items of the system at Level 2 and further break down those items into subsystems and components at Level 3. On the other hand, the Army uses a functional breakdown of A–T–L cost elements in addition to a hardware breakdown similar to that in MIL–STD–881A, thereby

establishing the Army Life Cycle Cost matrix. While the breakdown of A–T–L costs between the Army and the other two services are different, the breakdown of B–T–L costs are generally the same.

Another significant difference between the WBSs of the Services is that the Army treats peculiar and common support equipment as a breakdown of the structure whereas the Air Force and the Navy consider these as separate B–T–L cost elements in line with MIL–STD–881A. In most cases, CPRs on Army programs do not include peculiar and common support equipment since the structure is not broken down in those reports.

3.7 ACCOUNTING INCONSISTENCIES

Some B–T–L costs are not clearly defined and are often included in A–T–L costs or vice versa. For example, the category of Data may include drawings, specifications, parts lists, and test plans which may also be included under Development Engineering as A–T–L costs. Similarly, there is an overlap in test planning, data reduction, and test reports between Development Engineering and System Test and Evaluation. Drawing the line between what specific data items are A–T–L versus B–T–L can be difficult and therefore result in inconsistencies among various programs.

Another possible area of overlap is where some of the same people performing B–T–L functions are concurrently involved in the production of one model of a system and the development of the succeeding model of that system. This possibility exists particularly in the area of System/Program Management. Dividing those efforts equitably between the two contracts may be complicated and lead to inconsistencies in charging B–T–L costs.

3.8 ZERO VALUES

In many instances, the CPRs reviewed did not show a value for one or more of the cost elements. Where the data added up without those elements, it was assumed that the value of the cost element was zero. Where the data did not add up, the value was left blank. This made it unclear as to whether the value was actually zero, whether it was omitted, or whether that cost was covered under some other cost element.

The question of using zero values in determining mean values of the data also arose. Including zeros would bring the mean value down, but if it were known that for a new system being acquired a definite need existed for that product or service, a mean value that did not include zero values would be more realistic. Means were therefore calculated both ways; i.e., with and without zero values, however, in the final analysis, zero values were omitted for systems showing no costs for a particular cost element throughout the entire phase.

3.9 PROGRAM MAGNITUDE

When computing the means of data for programs with significant differences in cost magnitude, greater weight is automatically given to the programs with the highest costs. To overcome this problem, it was necessary to covert the data set for each system to percents of the total program so that all programs would be of equal weight.

3.10 PROGRAM INITIATION DATE

Where the SAR or some other authoritative source of information indicated the beginning of the EMD phase as later than the first year shown for start of research, development, test and evaluation (RDT&E) funding, the start of EMD (Milestone II) was selected as the first phase year. This was done since the start of RDT&E funding could have included one or more earlier phases of the program, i.e., demonstration and validation (Dem/Val) and even concept exploration. For production programs, the first phase year was selected on the basis of the start of procurement funding or Milestone III (production decision).

It was noted that certain CPRs reported expenditures for one year, but indicated that the program year (funding FY) was one or two years earlier. In some cases, the annual production quantities shown in the CPR were one to two years out of phase with the program quantities shown in the SAR for that system. Since the phase year used was generally based on the first year of the program as shown in the SAR, the actual data from the CPR could be one or two years out of phase with that time frame. Where this discrepancy was noted, the beginning of the phase year was adjusted to reflect actual production expenditures.

3.11 FIRST AND LAST PHASE YEAR

The data for the first phase year may not be consistent among programs since the length of that year could vary from one month to twelve months depending upon the month in which the program was initiated or the contract awarded. The average length of the first phase year for development programs used in this study was actually five months. These inconsistencies would not only affect the first phase year but would have a ripple effect on each succeeding twelve-month period including the last year of the phase.

When complete data by month from the first month to the last month of the phase are available, it is possible to adjust the data to provide greater consistency in the results. For example, the first six months could be used as the first phase year for all systems regardless of when those months actually fell within the fiscal year, and the succeeding twelve month periods could be considered as the subsequent phase years until the phase was completed. This could be even further refined by breaking down all phase years into quarters with the results tailored to the number of quarters projected for any new program.

3.12 PROGRAM LENGTH

It soon became apparent that data for systems with different program lengths could not be compared directly since that would distort the results, especially for the latter years of the programs. It therefore became necessary to segregate the data sets by program length to ensure a valid comparison of the data, however, this reduced the size of the sample for each set of calculations. In the case of development programs, this problem was overcome by combining the results of the individual data sets for each cost element as described in Section 2.

3.13 FLYAWAY COSTS

Many programs report A-T-L costs in terms of "flyaway" cost, which is specifically defined in DoD Instruction 5000.33. Flyaway (also known as rollaway, sailaway, etc.) costs include System/Program Management and System Test and Evaluation, but no other B-T-L cost elements. This reduces the amount of data available for averaging System/Program Management and System Test and Evaluation costs since they are usually not reported separately when they are part of flyaway costs.

4. SYSTEM DEVELOPMENT

4.1 MAJOR ACTIVITIES

In order to appreciate the reasons for time variations in A–T–L and B–T–L costs, it is necessary to understand the major activities that are conducted during each phase of the acquisition cycle. The major contractor and government activities conducted during the EMD phase of a defense system are shown by year in Table 4.1–1 for a six–year cycle. The B–T–L cost elements most affected by the major activities in each year of the EMD are shown at the bottom of that table.

Except for System/Program Management and Data, both of which start at the beginning of the phase, the other B–T–L cost elements tend to have higher costs at the middle and later portions of the phase. This is especially true of System Test and Evaluation and Training.The breakdown of the EMD phase by year is merely to portray the progression of events throughout the phase rather than to indicate specific annual activities which can actually overlap two or more years. For other than six–year cycles, different tables would be required to show the distribution of the same activities in a fewer or greater number of years.

4.2 SYSTEM/PROGRAM MANAGEMENT

System/Program Management costs generally include the following:

- Program manager and staff members dedicated to the program
- Overhead for system/program management activities
- Matrix support from other organizations to system/program management activities
- System engineering activities, including reliability, maintainability, system safety engineering, human factors engineering, Integrated Logistic Support (ILS) planning, and related activities not covered under engineering development
- Travel and other direct costs associated with system/program management

Table 4.1-1 Major Activities in EMD Phase

First Year	Second Year	Third Year	Fourth Year	Fifth Year	Sixth Year
Preliminary Design of System	Advanced Design of System System Engineering: R&M, ILS, Safety, Health, Human Factors, Producibility Preliminary LSA	Fabricate Prototype Components Contractor Testing of Components LSA Task Analysis	System Integration Contractor Testing of System Draft Technical Publications Training Materials Provisioning Tech. Documentation	Training of Govt. Test Personnel Govt. Conduct Development Testing Govt. Conduct Operational Testing	Final Design of System Tech. Data Package Govt. Conduct Final Eval. of System Milestone III Decision
B-T-L Cost Elements Most Affected					
Sys/PM Data	Sys/PM Data Facilities Spt. Eqmt.	Sys/PM Data Facilities Spt. Eqmt. Sys T&E Training	Sys/PM Data Facilities Spt. Eqmt. Sys T&E Training	Sys/PM Data Facilities Spt. Eqmt. Sys T&E Training	Sys/PM Data Facilities Spt. Eqmt. Sys T&E Training

Figure 4.2–1 shows the System/Program Management cost profile for development programs in terms of percent of the total cost of System/Program Management for the entire EMD phase. This figure, as are the subsequent figures in this section, is shown for a six–year development program, but the profile is applicable to all phase lengths and the appropriate values can be determined by interpolation as explained in Chapter 3. In the EMD phase, the System/Program Management cost profile reflects a steady buildup in the first two years, peaking in the third year, and a gradual decline to the final year of a six–year program.

4.3 SYSTEM TEST AND EVALUATION

System Test and Evaluation activities during the EMD phase generally include the following:

- Test planning including the preparation of test plans for contractor tests
- Conduct of contractor tests including the use of contractor test personnel, test facilities, utilities, supplies, etc., to support the contractor tests
- Preparation of reports on contractor tests
- Support of government tests.

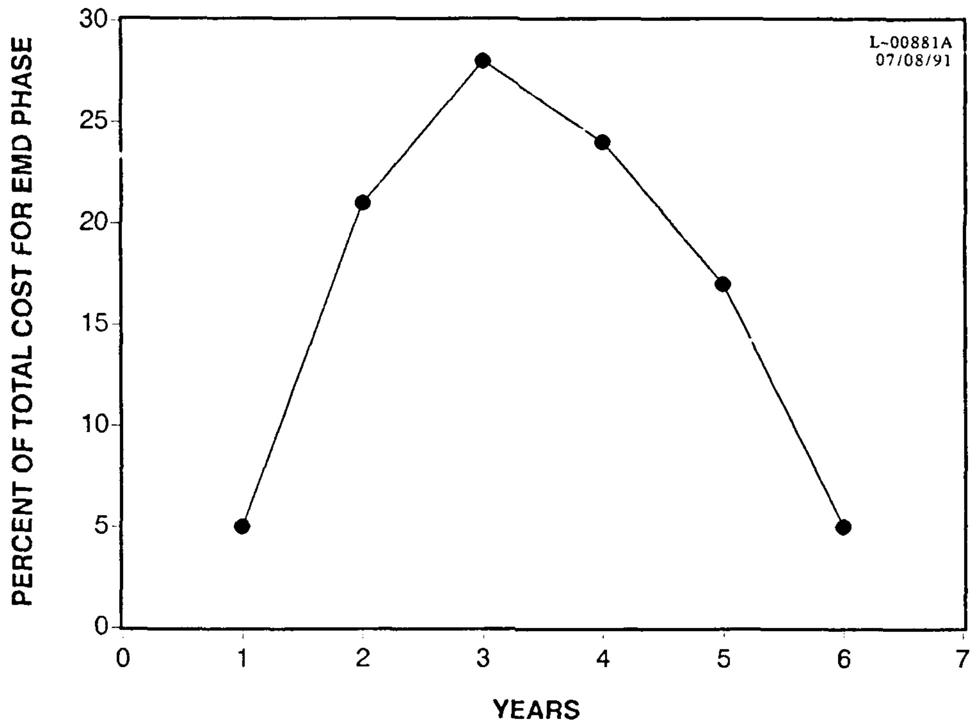

Figure 4.2–1 System/Program Management Cost Profile

Figure 4.3–1 shows the System Test and Evaluation cost profile for development programs in terms of percent of the total cost of System Test and Evaluation for the entire EMD phase. The profile clearly indicates a very low level of activity early in the phase when only planning takes place. The level of activity increases as components and subsystems are fabricated and tested and reaches a peak late in the phase when the completely integrated system is tested.

4.4 DATA

Contractor Data requirements for system development programs generally include the following:

- Engineering data not included in development engineering
- Reliability and maintainability (R&M) data, such as the results of the Failure Modes, Effects, and Criticality Analysis (FMECA)
- Logistics data, such as Logistic Support Analysis (LSA) data and provisioning data

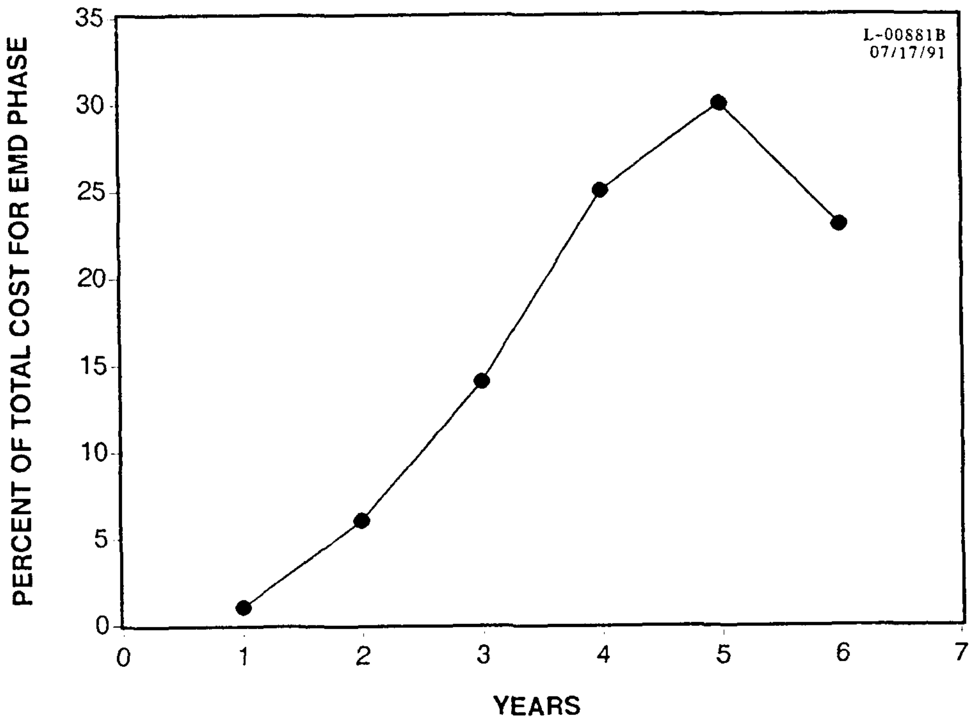

Figure 4.3-1 System Test and Evaluation Cost Profile

- Special data involving system safety, human factors, health hazards, environmental impact, etc.
- Technical publications (manuals and orders) providing instructions on the operation and maintenance of the system
- Management data, such as program status reports
- Other documents specified in the Contract Data Requirements List (CDRL).

Figure 4.4-1 shows the Data cost profile for development programs in terms of percent of total cost of Data for the entire EMD phase. The Data cost profile reaches a peak somewhat past the middle of the EMD phase. This reflects the higher level of activity later in the phase as logistics and provisioning data are generated and technical publications are prepared to support system test and evaluation and related training.

4.5 TRAINING SERVICES AND EQUIPMENT

Training activities during the EMD phase generally include the following:

- Preparation of contractor training plans

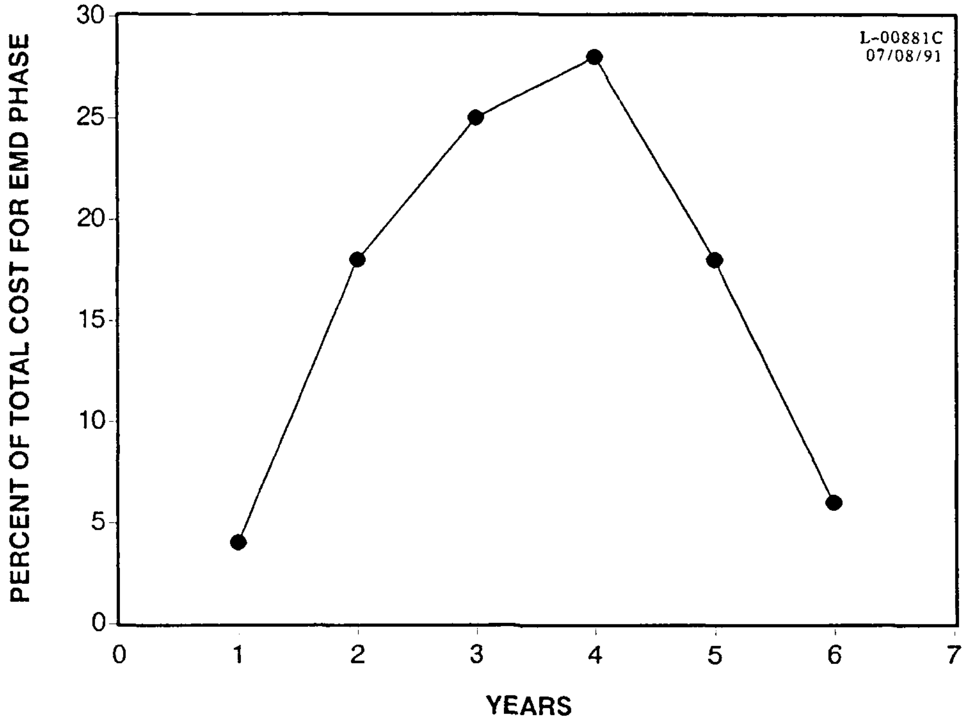

Figure 4.4–1 Data Cost Profile

- Development of training materials for use by contractor and government training activities
- Development of system unique training devices and simulators
- Conduct of contractor training for government personnel, including the provision of instructors, classroom and other facilities, equipment, supplies, etc.
- Supporting government training activities as required
- Preparing reports on training accomplished.

Figure 4.5–1 shows the Training cost profile for development programs in terms of percent of the total cost of Training for the entire EMD phase. As can be seen, the Training cost profile is similar to the System Test and Evaluation cost profile. Training costs at the beginning of the phase are low since only planning activities take place in that time frame. As the design of the system becomes more mature, the activity increases with the preparation of training packages. Training costs reach a peak later in the EMD phase as training is conducted for personnel who will conduct the test and evaluation of the system.

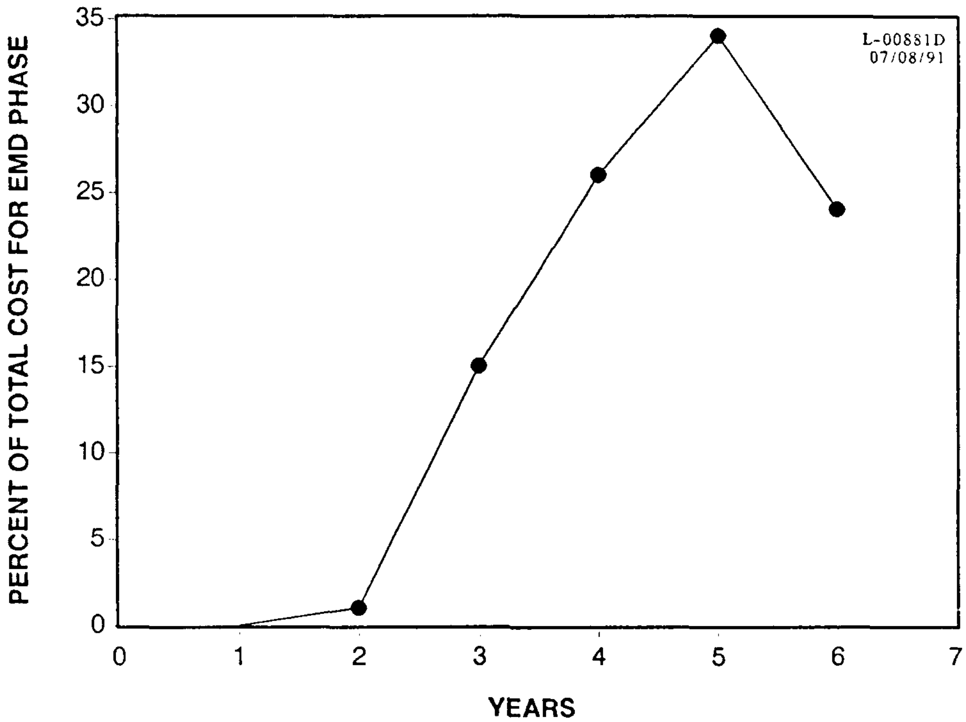

Figure 4.5-1 Training Cost Profile

4.6 FACILITIES

This cost element pertains to the construction of new facilities or the modification of existing facilities to accommodate the design, development, test, and evaluation of a system. Contractor costs for facilities are dependent upon requirements unique to each program and area therefore difficult to estimate. Where such costs have been incurred, available data indicates a cost profile as shown in Figure 4.6-1. This profile shows a buildup from the planning stage early in the phase to a peak of activity in the third and fourth years after which costs decline to the end of the phase.

4.7 SUPPORT EQUIPMENT

As explained above, the Air Force and the Navy list Support Equipment as a separate B-T-L cost element in accordance with MIL-STD-881A. The Army, on the other hand, considers Support Equipment as part of the structure (hardware) breakdown. As a result, available data in CPRs on Support Equipment is not consistent.

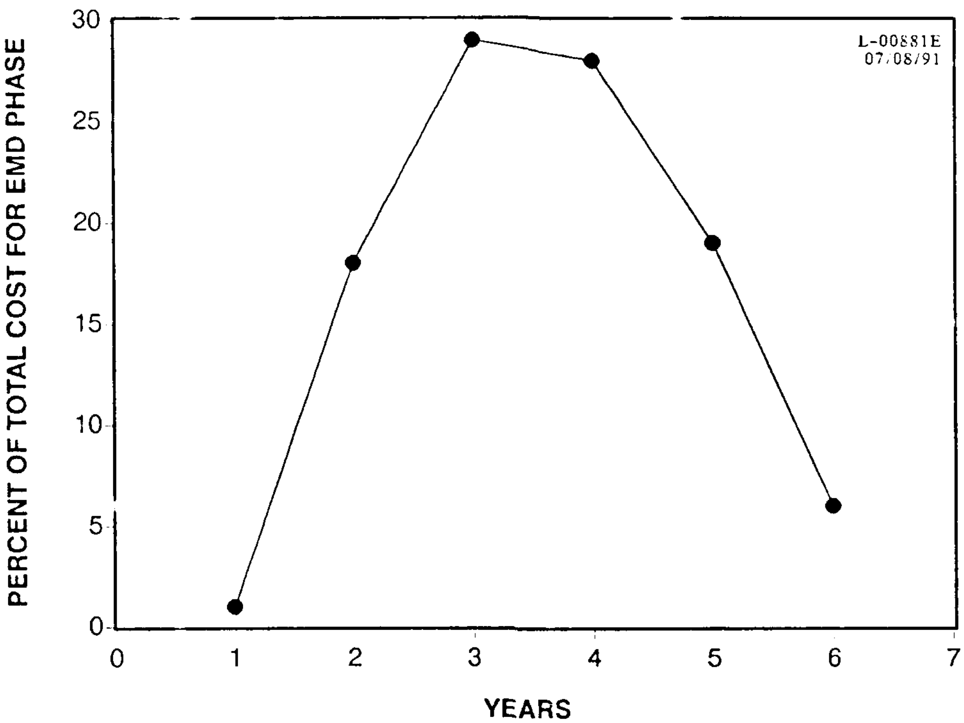

Figure 4.6-1 Facilities Cost Profile

Contractor charges to this cost element would involve primarily the development of peculiar test equipment, shop equipment, and other items of equipment required for the operation or support of the system. Since existing (common) s pport equipment is often adequate to suppor. the new weapon system, peculiar (development) support equipment may not always be required. When required, Support Equipment exhibits a cost profile as shown in Figure 4.7-1. This profile reflects the steady increase in Support Equipment costs early in the program, reaching a peak in the fourth year when the equipment is required to support test and evaluation of the integrated system, and a rapid drop after that has been accomplished.

4.8 SUMMARY OF RESULTS

Based on the profiles for the various cost elements addressed above, the time-phased distribution of total program costs by each year of the development phase were determined. Tables 4.8-1, 4.8-2, and 4.8-3 provide that distribution in terms of percent of total program cost for six-year, five-year, and four-year programs, respectively. Distribution factors for programs of other phase lengths may be calculated by interpolation or by plotting the distribution for

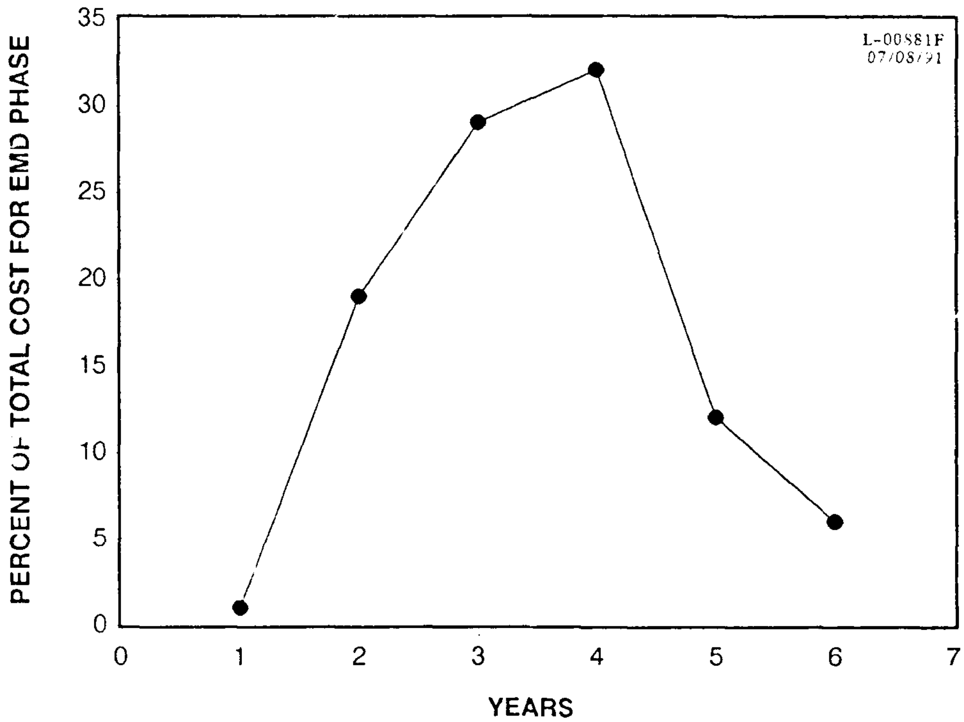

Figure 4.7–1 Support Equipment Cost Profile

six–year programs and using a different scale between the first and last years to represent the year desired.

Table 4.8–1 Distribution of B–T–L Costs for Six–Year Development Programs

Cost Element	Percent of Program Cost by Phase Year						
	1	2	3	4	5	6	Total
System/Program Mgmt.	5	21	28	23	18	5	100
System Test & Evaluation	1	6	14	25	30	23	100
Data	4	18	25	28	18	6	100
Training	0	1	15	26	34	24	100
Facilities	1	18	29	28	19	6	100
Support Equipment	1	19	29	32	12	6	100

Table 4.8-2 Distribution of B-T-L Costs for Five-Year Development Programs

Cost Element	Percent of Program Cost by Phase Year					
	1	2	3	4	5	Total
System/Program Mgmt.	6	29	33	25	6	100
System Test & Evaluation	1	10	24	36	29	100
Data	5	26	34	27	8	100
Training	1	5	25	40	29	100
Facilities	2	27	37	27	8	100
Support Equipment	2	28	40	23	8	100

Table 4.8-3 Distribution of B-T-L Costs for Four-Year Development Programs

Cost Element	Percent of Program Cost by Phase Year				
	1	2	3	4	Total
System/Program Mgmt.	9	45	38	9	100
System Test & Evaluation	1	13	43	37	100
Data	7	39	43	10	100
Training	1	18	45	38	100
Facilities	2	44	44	10	100
Support Equipment	2	44	44	10	100

Confidence limits for the cost factors identified in Tables 4.8-1, 4.8-2, and 4.8-3 are provided for each cost element in Tables 4.8-4 thru 4.8-9, respectively. While the cost factors are based on the normalized mean values of data from all 19 systems, the confidence limits shown were calculated from the data on only those systems in each group (four-year, five-year, and six-year programs) for which data was available.

In the case of Training, there was insufficient data in each group of systems to calculate confidence limits for the cost factors shown. Although many of the 19 systems analyzed had zero values for training throughout the development phase, there was a sufficient sample to arrive at mean values for that cost element in each year of that phase. However, when broken down into the three groups for different program lengths, the sample in each group became too small to provide reasonable results. This condition was also true of Facilities in the case of six-year programs.

Table 4.8–4 Confidence Limits for System/Program Management Cost Factors

Description	Percent of Program Cost by Phase Year						
	1	2	3	4	5	6	Total
Four-Year Programs							
Upper 90% Conf. Limit	49	61	49	15			
Upper 50% Conf. Limit	30	51	39	10			
Expected Value	9	45	38	9			100
Lower 50% Conf. Limit	5	36	25	3			
Lower 90% Conf. Limit	0	26	15	0			
Five-Year Programs							
Upper 90% Conf. Limit	17	40	43	31	18		
Upper 50% Conf. Limit	11	34	36	26	12		
Expected Value	6	29	33	25	6		100
Lower 50% Conf. Limit	4	27	27	19	4		
Lower 90% Conf. Limit	0	22	21	14	2		
Six-Year Programs							
Upper 90% Conf. Limit	17	45	40	31	28	13	
Upper 50% Conf. Limit	10	33	34	25	21	8	
Expected Value	5	21	28	23	18	5	100
Lower 50% Conf. Limit	0	17	25	16	11	2	
Lower 90% Conf. Limit	0	4	18	10	4	0	

Table 4.8–5 Confidence Limits for System Test and Evaluation Cost Factors

Description	Percent of Program Cost by Phase Year						
	1	2	3	4	5	6	Total
Four-Year Programs							
Upper 90% Conf. Limit	3	60	92	57			
Upper 50% Conf. Limit	2	39	69	39			
Expected Value	1	18	43	37			100
Lower 50% Conf. Limit	0	9	38	8			
Lower 90% Conf. Limit	0	0	15	0			
Five-Year Programs							
Upper 90% Conf. Limit	3	21	57	89	68		
Upper 50% Conf. Limit	2	12	33	65	44		
Expected Value	1	10	24	36	29		100
Lower 50% Conf. Limit	0	0	0	32	13		
Lower 90% Conf. Limit	0	0	0	7	0		
Six-Year Programs							
Upper 90% Conf. Limit	2	23	36	72	49	53	
Upper 50% Conf. Limit	1	13	24	47	34	35	
Expected Value	1	6	14	25	30	23	100
Lower 50% Conf. Limit	0	0	8	14	15	9	
Lower 90% Conf. Limit	0	0	0	0	0	0	

Table 4.8–6 Confidence Limits for Data Cost Factors

Description	Percent of Program Cost by Phase Year						
	1	2	3	4	5	6	Total
Four-Year Programs							
Upper 90% Conf. Limit	42	66	54	54			
Upper 50% Conf. Limit	25	46	44	33			
Expected Value	7	39	43	10			100
Lower 50% Conf. Limit	1	19	29	4			
Lower 90% Conf. Limit	0	0	18	0			
Five-Year Programs							
Upper 90% Conf. Limit	9	34	54	43	22		
Upper 50% Conf. Limit	7	28	42	35	15		
Expected Value	5	26	34	27	8		100
Lower 50% Conf. Limit	1	19	26	24	6		
Lower 90% Conf. Limit	0	13	15	15	0		
Six-Year Programs							
Upper 90% Conf. Limit	8	56	57	56	31	10	
Upper 50% Conf. Limit	6	37	38	41	20	8	
Expected Value	4	18	25	25	18	6	100
Lower 50% Conf. Limit	0	12	13	21	6	2	
Lower 90% Conf. Limit	0	0	0	6	0	0	

Table 4.8–7 Confidence Limits for Training Cost Factors

Description	Percent of Program Cost by Phase Year						
	1	2	3	4	5	6	Total
Four-Year Programs							
Upper 90% Conf. Limit							
Upper 50% Conf. Limit							
Expected Value	1	18	45	38			100
Lower 50% Conf. Limit							
Lower 90% Conf. Limit							
Five-Year Programs							
Upper 90% Conf. Limit							
Upper 50% Conf. Limit							
Expected Value	1	5	25	40	29		100
Lower 50% Conf. Limit							
Lower 90% Conf. Limit							
Six-Year Programs							
Upper 90% Conf. Limit							
Upper 50% Conf. Limit							
Expected Value	0	1	15	26	34	24	100
Lower 50% Conf. Limit							
Lower 90% Conf. Limit							

Note: There was insufficient data in each group of programs to calculate meaningful confidence limits (see text).

Table 4.8–8 Confidence Limits for Facilities Cost Factors

Description	Percent of Program Cost by Phase Year						
	1	2	3	4	5	6	Total
Four-Year Programs							
Upper 90% Conf. Limit	5	54	58	25			
Upper 50% Conf. Limit	3	51	49	15			
Expected Value	2	44	44	10			100
Lower 50% Conf. Limit	0	42	37	0			
Lower 90% Conf. Limit	0	40	28	0			
Five-Year Programs							
Upper 90% Conf. Limit	9	50	56	29	12		
Upper 50% Conf. Limit	5	39	44	28	15		
Expected Value	2	27	37	27	8		100
Lower 50% Conf. Limit	0	24	28	27	0		
Lower 90% Conf. Limit	0	14	16	27	0		
Six-Year Programs							
Upper 90% Conf. Limit							
Upper 50% Conf. Limit							
Expected Value	1	18	25	28	18	6	100
Lower 50% Conf. Limit							
Lower 90% Conf. Limit							

Note: There was insufficient data for six-year programs to calculate meaningful confidence limits (see text).

Table 4.8–9 Confidence Limits for Support Equipment Cost Factors

Description	Percent of Program Cost by Phase Year						
	1	2	3	4	5	6	Total
Four-Year Programs							
Upper 90% Conf. Limit	19	66	66	32			
Upper 50% Conf. Limit	13	60	60	20			
Expected Value	2	44	44	10			100
Lower 50% Conf. Limit	0	17	17	3			
Lower 90% Conf. Limit	0	7	7	0			
Five-Year Programs							
Upper 90% Conf. Limit	19	65	60	58	69		
Upper 50% Conf. Limit	13	38	50	41	44		
Expected Value	2	28	40	23	8		100
Lower 50% Conf. Limit	0	19	11	17	2		
Lower 90% Conf. Limit	0	1	0	0	0		
Six-Year Programs							
Upper 90% Conf. Limit	3	47	77	89	26	34	
Upper 50% Conf. Limit	2	26	53	63	14	14	
Expected Value	1	19	29	32	12	6	100
Lower 50% Conf. Limit	0	0	22	23	3	0	
Lower 90% Conf. Limit	0	0	2	0	1	0	

5. SYSTEM PRODUCTION

5.1 MAJOR ACTIVITIES

The major contractor and government activities conducted during the production phase of a weapon system are shown by year in Table 5.1–1. The B–T–L cost elements most affected in each year of the production phase as shown at the bottom of Table 5.1–1. As can be seen, System/Program Management and Initial Spares continue throughout the production phase, however, the other cost elements are most affected during the first three years of that phase. This is not intended to imply that there are no costs for those elements, but rather a reduced level of expenditures in the later years of that phase. While the chart extends only to the sixth year of the production phase, the activities shown in the last year would be continued for as long as the system is in production.

Table 5.1–1 Major Activities in Production Phase

First Year	Second Year	Third Year	Fourth Year	Fifth Year	Sixth Year
Preparation for Production: Planning, Facilities, Tooling, Materials, Workforce, Quality, etc.	Initial Production Contractor Testing Government First Article Testing Initial Deliveries Institutional Training of Govt. Personnel Publication of Tech. Manuals Initial Provisioning of Spares	Full Rate Production Initial Deployment of System On–Site Training of Govt. Personnel Initial Operational Capability	Full Rate Production Continued Deployment of System	Full Rate Production Continued Deployment of System	Full Rate Production Continued Deployment of System
B–T–L Cost Elements Most Affected					
Sys/PM Spares Data Training Spt. Eqmt. Sys T&E	Sys/PM Spares Data Training Spt. Eqmt. Sys T&E	Sys/PM Spares Data Training Spt. Eqmt.	Sys/PM Spares	Sys/PM Spares	Sys/PM Spares

5.2 SYSTEM/PROGRAM MANAGEMENT

System/Program Management activities in the production phase are generally similar to those for the EMD phase and include the following:

- Program manager and staff dedicated to the program
- Overhead for system/program management activities
- Matrix support from other organizations to system/project management activities
- Travel and other direct costs associated with system/project management
- Residual system engineering and other engineering activities not covered in A-T-L costs.

This cost element remains fairly constant from year to year in the production phase, except for an increase in the second year due to greater activity in support of the initial delivery and deployment of the system. In the absence of any major production problems, System/ Program Management activities would tend to decline toward the end of the production phase.

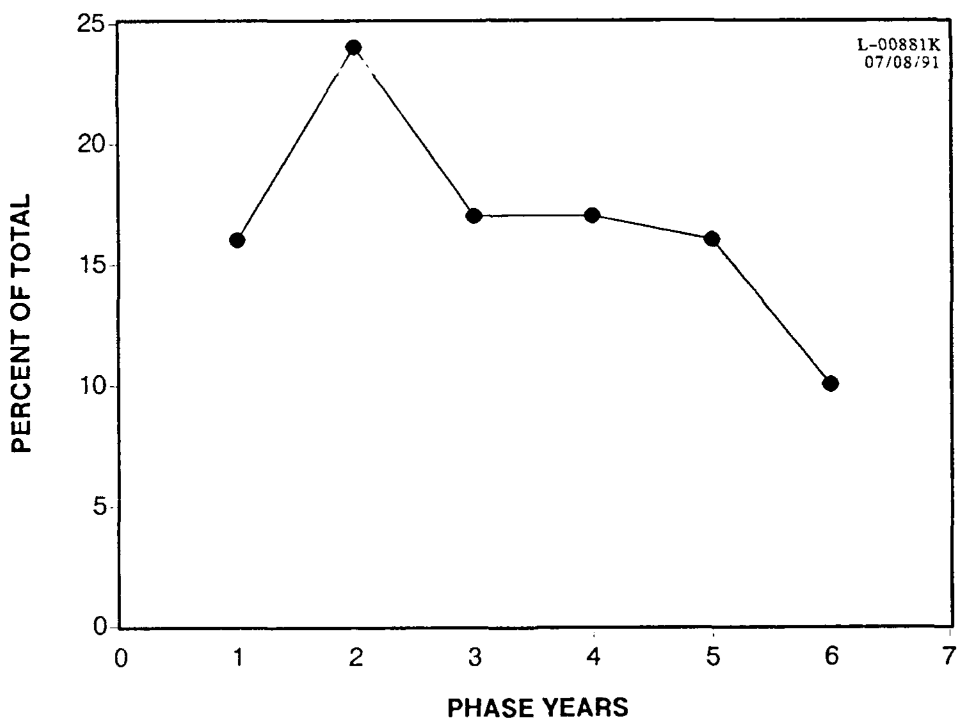

Figure 5.2-1 System/Program Management Cost Profile

5.3 SYSTEM TEST AND EVALUATION

System Test and Evaluation activities during the production phase generally include the following:

- Conduct of contractor tests to verify the correction of equipment hardware and software deficiencies detected in earlier tests
- Support of government first article tests and any further government testing required on sample items from system production

System Test and Evaluation is generally at a much lower level of effort in the production phase than in the EMD phase. It occurs primarily at the beginning of the production phase and tapers off as production quality improves. This trend is reflected in Figure 5.3–1 which shows the average costs for System Test and Evaluation during the first six years of the production phase.

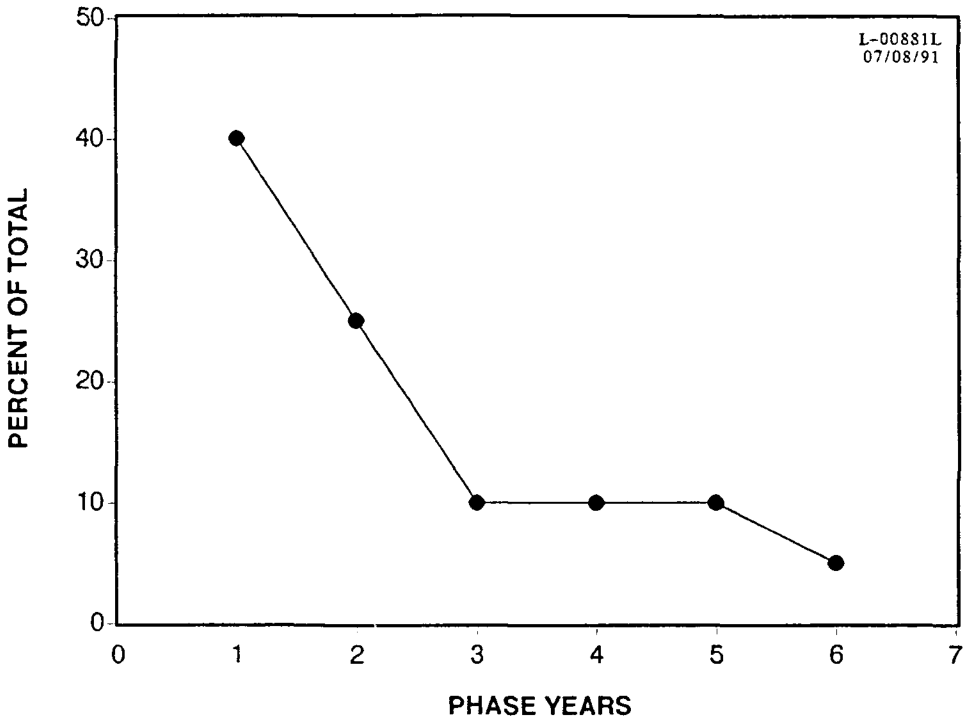

Figure 5.3–1 System Test and Evaluation Cost Profile

5.4 DATA

Contractor data requirements for system production programs generally include the following:

- Update of existing technical and logistics data as required
- Update of technical manuals and orders as required
- Production program data
- Other documents specified in the Contract Data Requirements List (CDRL)

Data requirements are generally higher at the beginning of the production phase and then tend to decline as the generation of new data is reduced. This trend is reflected in Figure 5.4–1 which shows the average costs for Data during the first six years of the production phase.

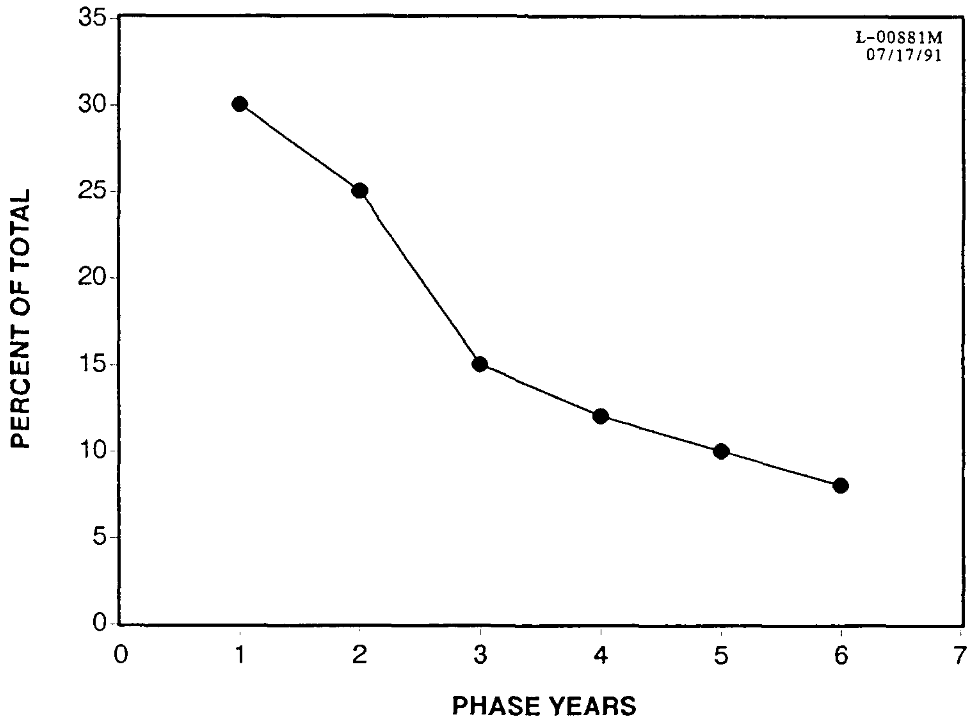

Figure 5.4–1 Data Cost Profile

5.5 TRAINING

Training activities in the production phase are generally a continuation of training activities initiated in the EMD phase, including the following:

- Preparation of contractor training plans
- Finalization of training materials required for use by contractor and government training activities
- Production of system unique training devices and simulators
- Conduct of contractor training for government personnel
- Supporting government training activities as required
- Preparing reports on training accomplished.

Contractor training activities would be at their peak just prior to, during, and immediately after initial deployment of the system, which is relatively early in the production phase. Contractor training would then decline as more systems are deployed and the government achieves the capability to conduct the required training in-house. For certain high-technology systems, there may be a requirement for some continued contractor training support throughout the production phase. Figure 5.5-1 shows the average costs for Training during the first six years of the production phase.

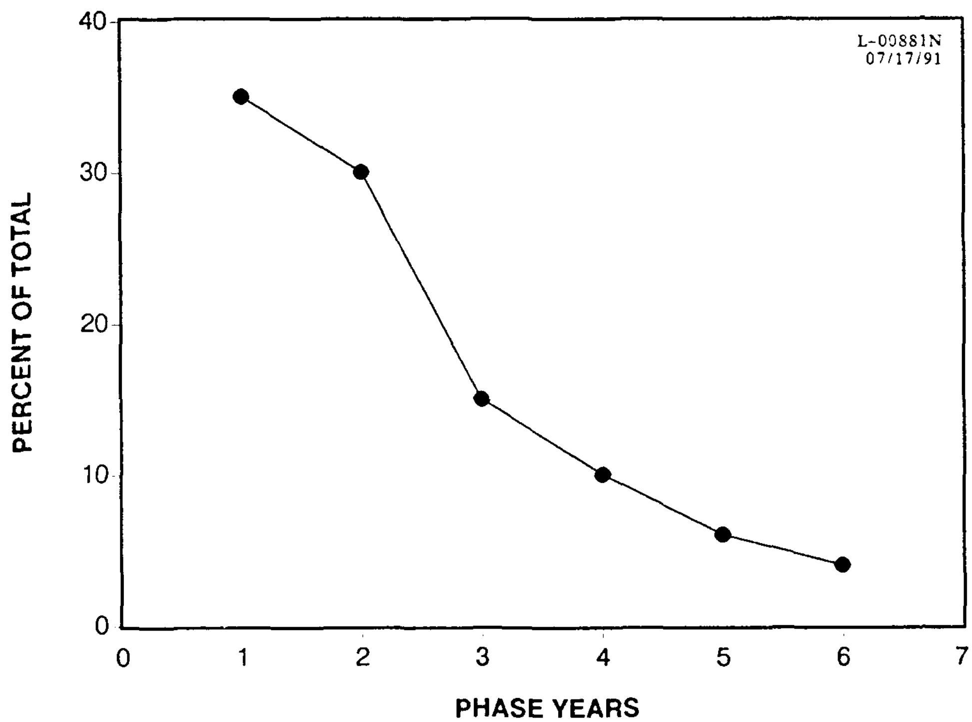

Figure 5.5-1 Training Cost Profile

5.6 OPERATIONAL/SITE ACTIVATION

This cost element involves the support that contractors provide to the government when required to establish an operational capability for the system. Most CPRs reviewed reflect zero costs for this activity, indicating little contractor participation. Costs must therefore be estimated on the basis of the unique circumstances associated with each case.

5.7 SUPPORT EQUIPMENT

Support Equipment under system production is subject to the same inconsistencies in WBS as described in Section 4. This cost element covers the production costs of peculiar test equipment and other items of equipment required for the operation or support of the system.

Figure 5.7-1 shows the cost profile for Support Equipment based upon very little actual data since many programs show no costs for this cost element. Where costs were incurred, the trend appeared to be relatively high for the first two years of the production phase with a sharp drop and leveling out before declining in the last year of the phase. This profile reflects early procurement of most Support Equipment requirements with some small residual procurement action later in the production phase.

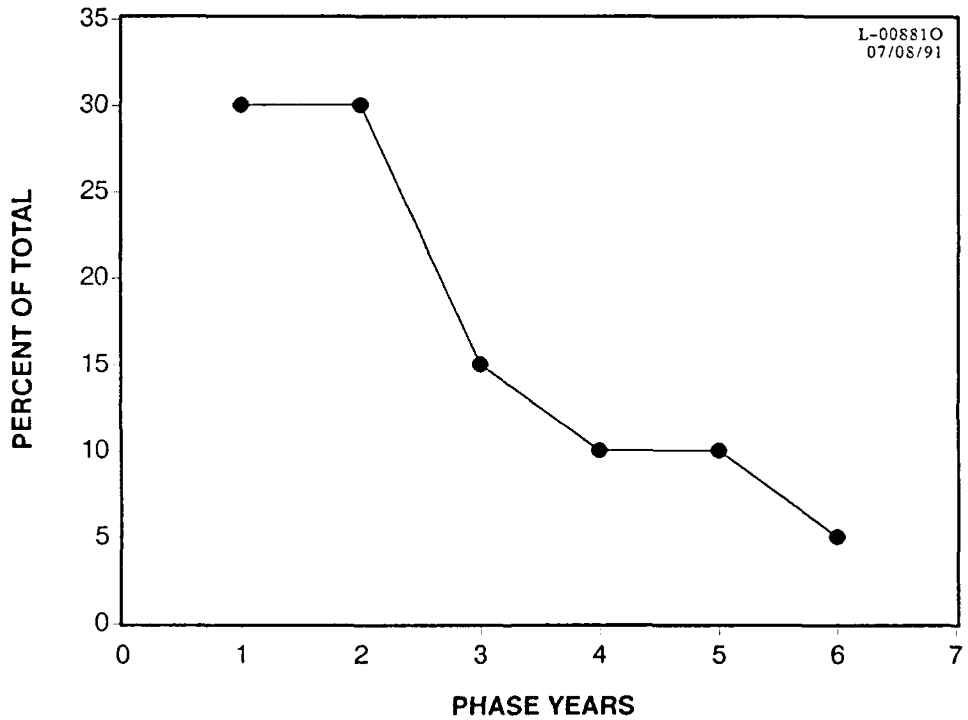

Figure 5.7-1 Support Equipment Cost Profile

5.8 INITIAL SPARES

This cost element includes the costs associated with the procurement of spare components to support the initial deployment of the system. Accounting for this cost element may be complicated if the actual production of those hardware items are included in the A-T-L cost element of Manufacturing.

Figure 5.8-1 shows the average costs for Initial Spares in the first six years of the production phase. Initial Spares costs are relatively constant throughout most of the production phase but with a moderate rise in the second year of that phase. The rise in the second year reflects a somewhat higher level of spares procurement to support initial deployment of the system and to fill the supply pipeline. After that, the cost of spares procurement levels off to support continuing deployment of the system to other users. Contractor costs for the Initial Spares are not affected by Government accounting for Initial Spares under Procurement versus Stock Fund accounts.

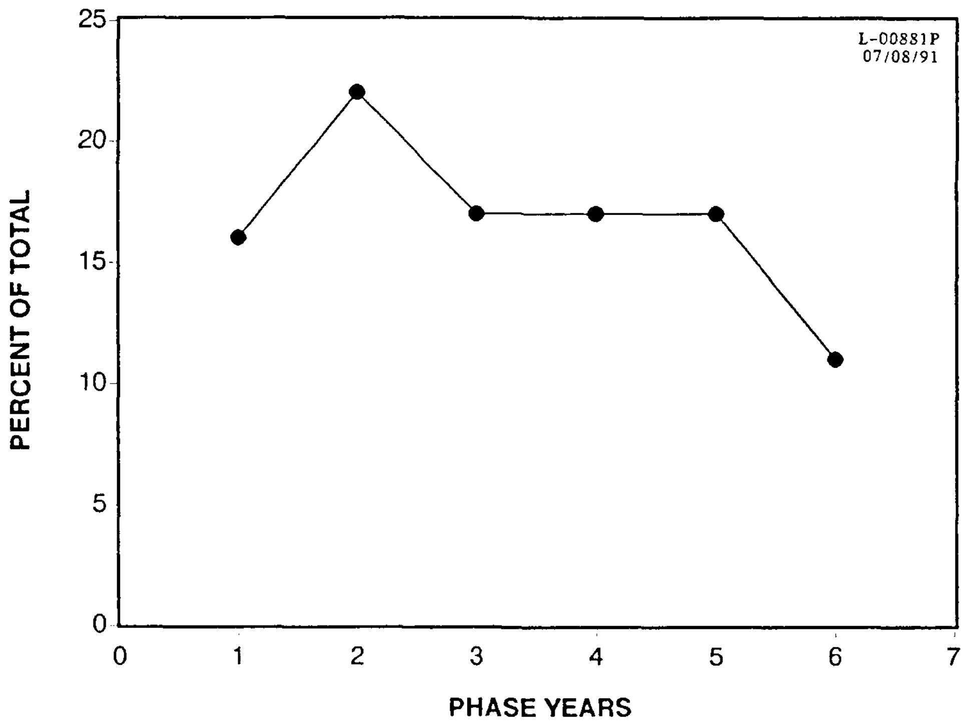

Figure 5.8-1 Initial Spares Cost Profile

5.9 SUMMARY OF RESULTS

Based on the profiles for the various cost elements, the time-phased distribution of total program costs by each year of the production phase were determined. Tables 5.9-1 through 5.9-4 provide that distribution in terms of percent of total program cost for six-year, five-year, four-year, and three-year programs respectively. Distribution factors for programs of other phase lengths may be calculated by interpolation or by plotting the distribution for six-year programs and using a different scale before the first and last years to represent the year desired.

Table 5.9-1 Distribution of B-T-L Costs for Six-Year Production Programs

Cost Element	Percent of Program Cost by Phase Year						
	1	2	3	4	5	6	Total
System/Program Mgmt.	16	24	17	17	16	10	100
System Test & Evaluation	40	25	10	10	10	5	100
Data	30	25	15	12	10	8	100
Training	35	30	15	10	6	4	100
Op/Site Activation*	--	--	--	--	--	--	--
Support Equipment	30	30	15	10	10	5	100
Initial Spares	16	22	17	17	17	11	100

*Insufficient data (values mostly zero)

Table 5.9-2 Distribution of B-T-L Costs for Five-Year Production Programs

Cost Element	Percent of Program Cost by Phase Year					
	1	2	3	4	5	Total
System/Program Mgmt.	20	29	20	20	10	100
System Test & Evaluation	40	30	12	12	6	100
Data	32	27	18	15	8	100
Training	40	30	15	10	5	100
Op/Site Activation*	--	--	--	--	--	--
Support Equipment	30	30	20	13	7	100
Initial Spares	18	30	20	20	12	100

*Insufficient data (values mostly zero)

Table 5.9–3 Distribution of B–T–L Costs for Four–Year Production Programs

Cost Element	Percent of Program Cost by Phase Year				
	1	2	3	4	Total
System/Program Mgmt.	30	45	20	10	100
System Test & Evaluation	40	30	20	10	100
Data	35	30	20	15	100
Training	45	30	20	5	100
Op/Site Activation*	--	--	--	--	--
Support Equipment	30	30	25	15	100
Initial Spares	20	35	30	15	100

*Insufficient data (values mostly zero)

Table 5.9–4 Distribution of B–T–L Costs for Three–Year Production Programs

Cost Element	Percent of Program Cost by Phase Year			
	1	2	3	Total
System/Program Mgmt.	40	45	15	100
System Test & Evaluation	40	30	30	100
Data	40	35	25	100
Training	45	30	2[illegible]	100
Op/Site Activation*	--	--	--	--
Support Equipment	35	35	30	100
Initial Spares	25	40	35	100

*Insufficient data (values mostly zero)

The results for the production phase are based on only 12 systems for which complete data were available compared with 19 systems for the development phase. The development phase constitutes a relatively well structured process which allowed for the combination of data on systems with different phase lengths. On the other hand, the production phase is open–ended depending upon the length of the program with most B–T–L activities occurring within the first three years of the phase. These factors make it more difficult to arrive at credible results for the production phase.

The data available did support our conclusions based on an in–depth knowledge of the acquisition process and contractual requirements for B–T–L products and services during the production phase as described in the previous paragraphs of this section. The results were also compared against data segments for other systems on which complete data was not available to

further reinforce their validity. These data segments were analyzed for magnitude and trends between successive years to determine their consistency with the results.

The results obtained from each data set of six-year, four-year, and three-year programs were adjusted to reflect the results of the other data sets and even partial data where such data indicated definite time-phased trends. This in effect increased the size of the database, but not to the same degree of precision as was accomplished for the development phase. In the absence of any data for systems with a phase length of five years, the results for five-year programs were interpolated from the results of six-year and four-year programs.

While the above factors tend to add credibility to the results, their effect cannot be mathematically calculated as a measure of confidence. In fact, the limited sample made it impossible to calculate meaningful confidence levels for some of the production phase results. The problem with the limited number of systems was exacerbated by several systems having zero values for certain cost elements (i.e., System Test and Evaluation, Training, Operational/Site Activation, and Support Equipment), which further reduced the size of the sample in those cases.

Confidence limits for System/Program Management, Data, and Initial Spares for six-year production programs are shown in Tables 5.9-5, 5.9-6, and 5.9-7, respectively. As indicated above, insufficient data was available to calculate confidence limits for System Test and Evaluation, Training, Operational/Site Activation, or Support Equipment. Also, the sample size for three and four-year programs was too small to calculate meaningful confidence limits for any cost element, including System/Program Management, Data, and Initial Spares.

The confidence limits shown are based on the actual data set for six-year programs, however, the expected values do not represent the means of that data set since the results were adjusted to accommodate other data sets and partial data as explained above. While this introduces some degree of mathematical error between the confidence limits and the corresponding expected values, the confidence limits are reasonably compatible with the expected values based on adjusted results and therefore can be used to determine the probable range of values in each year of the production phase.

Notwithstanding the lack of specific confidence limits for some of the production phase results, the combination of technical assessment with the limited data available makes those results far more credible than the alternative of using a straight-line average to distribute the total program cost for each B-T-L cost element equally in each year throughout the production phase. This is especially true in the case of System Test and Evaluation, Data, Training, and

Support Equipment which incur the greatest costs in the first two years of the production phase, i.e., over 50 percent of the total program costs for both years combined.

Table 5.9–5 Confidence Limits for System/Program Management Cost Factors

Cost Element	Percent of Program Cost by Phase Year						
	1	2	3	4	5	6	Total
Six-Year Programs							
Upper 90% Conf. Limit	30	30	21	22	19	18	
Upper 50% Conf. Limit	23	27	19	19	17	15	
Expected Value	16	24	17	17	16	10	100
Lower 50% Conf. Limit	12	17	14	15	15	8	
Lower 90% Conf. Limit	5	11	10	12	13	6	
Other Programs							
Insufficient Data to establish Confidence Limits							

Table 5.9–6 Confidence Limits for Data Cost Factors

Cost Element	Percent of Program Cost by Phase Year						
	1	2	3	4	5	6	Total
Six-Year Programs							
Upper 90% Conf. Limit	56	34	29	16	17	18	
Upper 50% Conf. Limit	39	28	22	14	15	12	
Expected Value	30	25	15	12	10	8	100
Lower 50% Conf. Limit	15	16	12	5	8	5	
Lower 90% Conf. Limit	0	14	7	2	6	1	
Other Programs							
Insufficient Data to establish Confidence Limits							

Table 5.9–7 Confidence Limits for Initial Spares Cost Factors

Cost Element	Percent of Program Cost by Phase Year						
	1	2	3	4	5	6	Total
Six-Year Programs							
Upper 90% Conf. Limit	65	49	26	22	26	29	
Upper 50% Conf. Limit	42	37	19	19	19	18	
Expected Value	16	22	17	17	17	11	100
Lower 50% Conf. Limit	11	20	7	5	8	3	
Lower 90% Conf. Limit	0	7	0	0	1	0	
Other Programs							
Insufficient Data to establish Confidence Limits							

6. CONCLUSIONS

A comparison of each B–T–L cost element with total A–T–L costs indicates no corresponding time–phased trends that could be used for determining cost estimating relationships (CERs) on an annual basis for each year in the development or production phase of major defense system acquisitions.

Due to insufficient data on functional A–T–L cost elements, it was impossible to determine whether any CERs existed between specific B–T–L cost elements and functional A–T–L cost elements on a time–phased basis.

Existing CERs used to determine the total program costs for each B–T–L cost element based on specific A–T–L cost elements or total A–T–L costs for each phase in the defense system acquisition cycle are still valid in the absence of any new CERs on a time–phased basis.

The available data, coupled with a technical evaluation of the activities associated with the defense system acquisition process, clearly indicate that the application of a straight–line average, allocating an equal percent of the total program cost of each B–T–L cost element in each year of the development or production phase, is not a suitable method for estimating B–T–L costs on an annual basis.

Although the source data for this study was limited, especially in the case of production programs, credible cost factors were developed for the allocation of total program costs for each B–T–L cost element by year throughout the development and production phases of major defense system acquisitions.

The results for development programs were based on a larger sample (19 systems) han production programs (12 systems), and due to the more structured nature of development programs, those results are subject to a higher level of confidence than those for production programs.

The results of this study can be refined as additional data becomes available and more sophisticated analytic techniques are developed for integrating partial data into the statistical analysis process and for adjusting data to accommodate program anomalies and technical differences between defense systems.

The results of this study can be expanded to cover specific phase lengths not addressed in this report and to accommodate variations in first year and last year cost factors due to different lengths of those years (one to twelve months depending on the start of the phase or the contract award date).

APPENDIX A
ACRONYMS AND ABBREVIATIONS

A. ACRONYMS AND ABBREVIATIONS

AFR	Air Force Regulation
AFSC	Air Force Systems Command
A-T-L	Above-the-line
AR	Army Regulation
ASD	Aeronautical Systems Division (AFSC)
B-T-L	Below-the-line
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CDSR	Cost Data Summary Report
CER	Cost Estimating Relationship
CLIN	Contract Line Item Number
CPR	Cost Performance Report
DA	Department of the Army
DoD	Department of Defense
EMD	Engineering and Manufacturing Development
FMECA	Failure Modes, Effects, and Criticality Analysis
FSD	Full-Scale Development (replaced by EMD)
FY	Fiscal Year
ILS	Integrated Logistics Support
INST	Instructions
LSA	Logistics Support Analysis
MIL-STD	Military Standard
Pam	Pamphlet

PDR	Prelimniary Design Review
PEP	Producibility Engineering and Planning
PRR	Production Readiness Review
R&M	Reliability and Maintainability
RDT&E	Research, Development, Test and Evaluation
SDIO	Strategic Defense Initiative Organization
SDS	Strategic Defense System
NAVAIR	Naval Air Systems Command
NAVMAT	Naval Materiel Command (extinct)
NAVSEA	Naval Sea Systems Command
OPNAV	Office of the Chief of Naval Operations
OSD	Office of the Secretary of Defense
SECNAV	Office of the Secretary of the Navy
SPAWAR	Space and Naval Warfare Systems Command
SSD	Space Systems Division (AFSC)
WBS	Work Breakdown Structure

APPENDIX B

REFERENCES

B. REFERENCES

Department of Defense

- DoD Directive 5000.4, October 30, 1980, OSD Cost Analysis Improvement Group
- DoD Instruction 5000.33, August 15, 1977, Uniform Budget/Cost Terms and Definitions
- DoD Instruction 7000.2, June 10, 1977, Performance Measurement for Selected Acquisitions
- DoD instruction 7000.10, Contract Cost Performance, Funds Status, and Cost/Schedule Status Reports
- DoD Instruction 7000.11, Contractor Cost Data Reporting

Department of the Army

- AR 11–18, 10 October 1975, The Cost Analysis Program
- DA Pam 11–2, 1 May 1976, Research and Development Cost Guide for Army Materiel Systems
- DA Pam 11–3, 12 April 1976, Investment Cost Guide for Army Materiel Systems
- DA Pam 11–4, 1 April 1976, Operating and Support Cost Guide for Army Materiel Systems
- DA Pam 11–5, 3 May 1976, Standards for Presentation of Life Cycle Cost Estimates for Army Materiel Systems
- Comptroller of the Army DCA–P–92(R), 15 May 1984, Instructions for Reformatting the BCE/ICE.

Department of the Air Force

- AFR 173–1, 10 October 1975, The Air Force Cost Analysis Program
- AFR 173–11, 7 October 1986, Independent Cost Analysis Program
- AFR 173–13, 2 September 1986, U.S. Air Force Cost and Planning Factors
- AFSC Cost Estimating Handbook Series, Volume VI — Space Handbook, December 1989
- SD–TR–88–97, Unmanned Space Vehicle Cost Model, Sixth Edition, November 1988.

Department of the Navy

- SECNAVINST 7000.15C, 17 March 1980, Contract Cost Performance, Fund Status, and Cost/Schedule Status
- SECNAVINST 7000.17C, 26 November 1986, Contractor Cost/Schedule Performance Measurement for Selected Acquisitions
- SECNAVINST 7000.19B, 12 March 1975, Department of the Navy Cost Analysis Program
- SECNAVINST 7000.20A, 25 August 1986, Cost Data Reporting Implementation
- NAVAIRINST 7000.8, 14 March 1980, Cost and Schedule Performance Measurement and Cost Reporting
- NAVMATINST 7000.17E, 26 August 1983, Cost Performance Measurement for Selected Acquisitions
- NAVMATINST 7000.19B, 27 May 1983, Cost Analysis Program Implementation
- OPNAVINST 7000.17A, 15 September 1976, Cost Analysis Program Implementation.

Joint Service Publications

- AMC–P 715–10, NAVMAT P5243, AFLCP/AFSCP 173–6, DLAH 8315.1, DCAAP 7641.46, 1 October 1984, Cost/Schedule Control Systems Criteria (C/SCSC) Joint Surveillance Guide
- DARCOM–P 715–13, NAVMAT P5244, AFLCP 173–2, AFSCP 173–3, DLAH 8315.3, 1 November 1978, Cost/Schedule Management of Non–Major Contracts (C/SSR Joint Guide)

Military Specifications and Standards

- MIL–STD–881A, 25 April 1975, Work Breakdown Structures for Defense Materiel Items.

APPENDIX C
WORK BREAKDOWN STRUCTURES

C. WORK BREAKDOWN STRUCTURES

This appendix contains a summary of the most typical WBSs used by DoD and the Military Services for cost accounting purposes. MIL-STD-881A, Work Breakdown Structures for Defense Materiel Systems, establishes the basic WBS for seven types of materiel systems (aircraft, electronics, missile, ordnance, ship, space, and surface vehicle). Under MIL-STD-881A, the system (Level 1) is first broken down into its major end items (Level 2) and then into its subsystems (Level 3). At Level 2, the system is also broken down into below-the-line functional cost elements.

Table C-1 contains a summary WBS for space systems based on the more complete WBS established in MIL-STD-881A. Table C-2 contains a variation of that WBS established by Space Systems Division, Air Force Systems Command, for space systems under its cognizance. The Navy generally follows the guidance contained in MIL-STD-881A, but may use variations of those WBSs for system acquisition contracts.

Instead of a one-dimensional WBS, as used by the other Services, the Army uses a two-dimensional matrix as shown in Table C-3. The Army Life Cycle Cost matrix consists of a Work Breakdown Structure of functional cost elements associated with Research and Development, Investment, and Operating and Support functions on one axis and a breakdown of the system structure on the other axis.

Table C-4 shows an updated version of the Army Life Cycle Cost matrix outlined in Table C-3. Certain cost elements have been rearranged and further broken down. Operating and Support cost elements have been broken down and restructured under Military Construction, Fielding, and Sustainment. The breakdown of the system structure in Table C-4 is identical to that in Table C-3.

Table C-1 Space System Work Breakdown Structure (MIL-STD-881A)

1.	**Space System**		
	1.1	Launch Vehicle	
		1.1.1	Integration and Assembly
		1.1.2-7	Various Components
	1.2	Stage Vehicle	
		1.2.1	Integration and Assembly
		1.2.2-3	Various Components
	1.3	Space Vehicle	
		1.3.1	Integration and Assembly
		1.3.2-7	Various Components
	1.4	Ground Communications, Command and Control Equipment	
		1.4.1-6	Various Elements
	1.5	Training	
		1.5.1	Equipment
		1.5.2	Services
		1.5.3	Facilities
	1.6	Peculiar Support Equipment	
	1.7	System Test and Evaluation	
	1.8	System/Project Management	
		1.8.1	System Engineering
		1.8.2	Project Management
	1.9	Data	
	1.10	Operational/Site Activation	
	1.11	Flight Support Operations and Services	
		1.11.1	Launch
		1.11.2	Flight
		1.11.3	Recover
	1.12	Common Support Equipment	
	1.13	Industrial Facilities	
	1.14	Initial Spares and Repair Parts	

NOTE: The WBS for Missile System is similar to the above, except that at Level 2 the system hardware is broken down into two components: (1) Air Vehicle and (2) Command and Launch Equipment. Below-the-line cost elements are the same.

Table C-2 Space System Work Breakdown Structure (SSD, AFSC)

1.	**Space System**		
	1.1	Launch Vehicle	
		1.1.1	Integration, Assembly and Test
		1.1.2	Software
		1.1.3-7	Various Components
	1.2	Orbital Transfer Vehicle	
		1.2.1	Integration, Assembly and Test
		1.2.2	Software
		1.2.3-7	Various Components
	1.3	Space Vehicle	
		1.3.1	Integration, Assembly and Test
		1.3.2	Software
		1.3.3	Spacecraft
		1.3.4	Reentry Vehicle
		1.3.5	Payload
		1.3.6	Orbit Injector/Dispenser
	1.4	Shroud (Payload Fairing)	
		1.4.1	Integration, Assembly and Test
		1.4.2	Software
		1.4.3-7	Various Components
	1.5	Ground Communications, Command and Control, and Mission Equipment	
		1.5.1	Integration, Assembly and Test
		1.5.2	Software
		1.5.3-11	Various Components
	1.6	Peculiar Support Equipment	
	1.7	Common Support Equipment	
	1.8	Initial Spares and Repair Parts	
	1.9	Storage	
	1.10	System/Program Management	
		1.10.1	System Engineering
		1.10.2	Program Management
	1.11	System Test and Evaluation	
	1.12	System Data	
	1.13	System Training	
		1.13.1	Equipment
		1.13.2	Services
		1.13.3	Facilities
	1.14	Industrial Facilities	
	1.15	Operational/Site Activation	
	1.16	Flight Support Operations and Services	

Table C–3 Army Life Cycle Cost Matrix (DA Pamphlets 11–Series)

A. FUNCTIONAL BREAKOUT

1. Research and Development

- 1.1 Development Engineering
- 1.2 Producibility Engineering and Planning (PEP)
- 1.3 Tooling
- 1.4 Prototype Manufacturing
- 1.5 Data
- 1.6 System Test and Evaluation
- 1.7 System/Project Management
- 1.8 Training
- 1.9 Facilities
- 1.10 Other

2. Investment

- 2.1 Nonrecurring Investment
- 2.2 Production
- 2.3 Engineering Changes
- 2.4 System Test and Evaluation
- 2.5 Data
- 2.6 System/Project Management
- 2.7 Operational/Site Activation
- 2.8 Training
- 2.9 Initial Spares and Repair Parts
- 2.10 Transportation
- 2.11 Other

3. Operating and Support

B. SYSTEM STRUCTURE BREAKDOWN

1. Frame
2. Propulsion
3. Guidance, Control, and Communications
4. Fire Control
5. Armament
6. Payload/Ammunition
7. (To be specified)
8. Peculiar Support Equipment
9. Common Support Equipment
10. Other
11. Total
12. Percent

Table C–4 Army Life Cycle Cost Matrix (DCA–P92R)

A. FUNCTIONAL BREAKOUT

1. Development

- 1.1 Development Engineering
  - 1.1.1 Engineering
  - 1.1.2 Producibility Engineering and Planning (PEP)
  - 1.1.3 Tooling
  - 1.1.4 Prototype Manufacturing
- 1.2 Data
- 1.3 System Test and Evaluation
- 1.4 System/Project Management
- 1.5 Training Services and Equipment
- 1.6 Facilities
- 1.7 Other RDT&E Funded Development

2. Production

- 2.1 Nonrecurring Production
  - 2.1.1 Initial Production Facilities (IPF)
  - 2.1.2 Production Base Support (PBS)
  - 2.1.3 Depot Maintenance Production Equipment (DMPE)
  - 2.1.4 Other Nonrecurring Production
- 2.2 Recurring Production
  - 2.2.1 Manufacturing
  - 2.2.2 Recurring Engineering
  - 2.2.3 Sustaining Tooling
  - 2.2.4 Quality Control
- 2.3 Engineering Changes
- 2.4 Data
- 2.5 System Test and Evaluation
- 2.6 Training Services and Equipment
- 2.7 Initial Spares
- 2.8 Operational/Site Activation
- 2.9 Other Procurement Funded Production

3. Military Construction

4. Fielding

5. Replenishment

B. SYSTEM STRUCTURE BREAKDOWN

1. Frame
2. Propulsion
3. Guidance, Control, and Communications
4 Fire Control
5. Armament
6. Payload/Ammunition
7. (To be specified)
8. Peculiar Support Equipment
9. Common Support Equipment
10. Other
11. Total
12. Percent

APPENDIX D
PROGRAM FUNDING PROFILES

D. PROGRAM FUNDING PROFILES

This appendix contains data on the funding profiles of missiles and other systems that may be used for comparison with GPALS elements for cost estimating purposes. Table D-1 covers the funding profiles for development programs and Table D-2 covers the funding profiles for production prorams. Development programs start with the first year of the engineering and manufacturing development (EMD) phase and production programs begin with the year of the full-rate production decision. The cost figures in the tables reflect actual expenditures in the years indicated, as documented in Selected Acquisition Reports (SARs) and other government documents. The first year's figures often represent less than a full year of expenditures since programs do not necessarily start at the beginning of the year.

Table D-1 Funding Profiles for Development Programs

System	Program Cost in Each Year ($M)									
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Adv. Cruise Missile	40	151	540	314	54					
AMRAAM (120A)	141	214	198	211	94	33	19			
HARM (88B)	30	45	64	73	22	6				
HARPOON (84A)	5	19	42	72	92	69	17			
HELLFIRE (114A)	4	19	51	66	58	44	20	14	2	
LANTIRN	11	32	41	86	100	57	98	37	32	17
MAVERICK (IR)	43	50	39	12	4	2				
PATRIOT	130	182	214	228	126	73	50	43		
PHOENIX (54C)	10	7	24	38	35	33	23	3		
SPARROW (7M)	2	8	13	0	13	15	3	5		
SRAM II (131A)	6	12	30	65	134	47				
TOMAHAWK	119	210	154	106	134	144	118	135	79	74
TOW 2	5	10	26	23	6	2				

Table D–2 Funding Profiles for Production Programs

System	Program Cost in Each Year ($M)									
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
ALCM B (86B)	(1)	157	248	339	313	236	213	60		
HARM (88B)	88	196	282	205	239	55	19			
HARPOON (84A)	82	134	149	137	136	147	208	224	216	277
HELLFIRE (114A)	25	121	253	214	212	176	0	122	33	
LANTIRN	89	414	670	207	62					
MAVERICK (IR)	218	238	298	352	377	337	92	9	9	
PATRIOT	67	395	437	666	762	835	871	821	918	266
PHOENIX (54C)	107	133	157	224	294	320	254	221	217	96
SPARROW (7M)	118	323	349	342	301	321	370	275	88	21
SRAM A (69A)	115	200	139	110						
STINGER (92C)	183	194	148	12	12					
TOMAHAWK	31	195	234	216	343	561	689	706	650	206
TOW 2	118	206	194	221	222	186	104	110	26	

(1) Included in second year cost